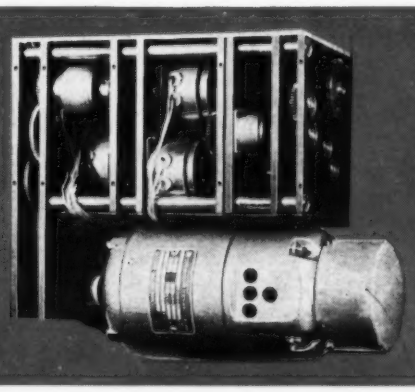
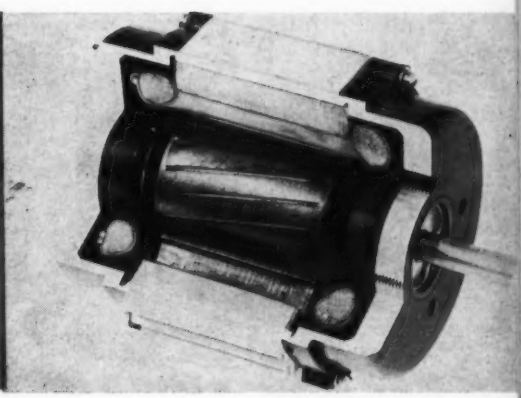
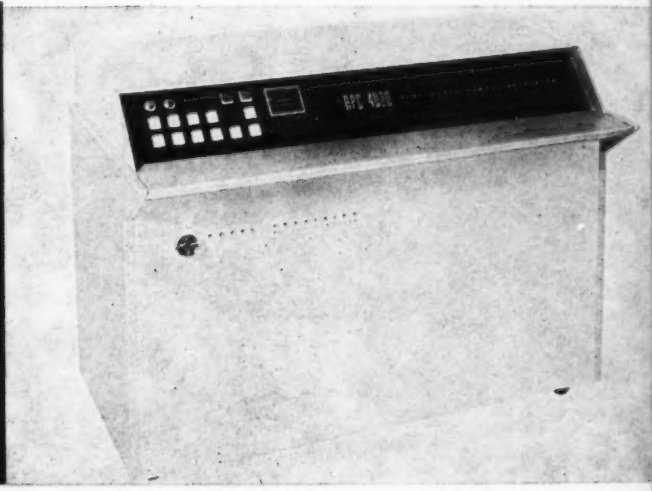
MILITARY SYSTEMS DESIGN

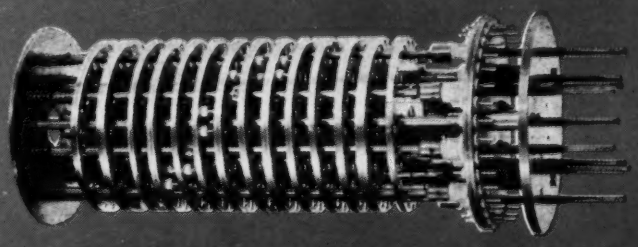
NOVEMBER-DECEMBER 1959

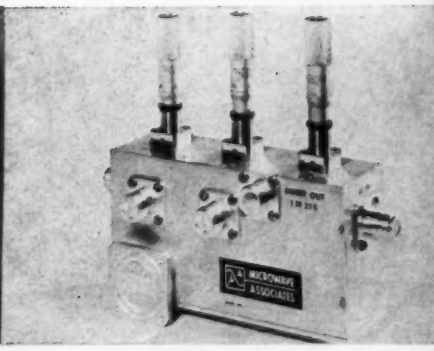
featuring: DELAY LINES • MICROWAVE COMPONENTS











INSTRUMENTS PUBLISHING COMPANY • PITTSBURGH 12, PENNSYLVANIA

SHAGGY FISH STORY

At the height of the Boston Tea Party, while the "Indians" were busy throwing everything in sight over the side, the British radar operator suddenly found himself pitched overboard.

Since he couldn't swim, he clung precariously to a wooden tea case bobbing in the water, and floated aimlessly around, thrashing wildly and yelling for help.

Just as he was about to lose his grip on his precious raft, a codfish surfaced nearby.

"What's going on here?" the codfish asked.

"Some wild Indians surprised our radar, overran the ship, and threw all the tea overboard," the radar man gasped.

"Well," the codfish said, "Bet you a fin you didn't have any Bomac tubes in that radar of yours."*

"Good cod, here I am drowning in front of your eyes and you have to give me a commercial," the man said. "I can't hang on much longer!"

The fish ignored him. " . . . Anybody knows Bomac makes the finest microwave tubes and components either side of Boston Harbor," he said.

"Look," the man said. "I've just about haddock. But tell me this: How do you know so much about microwaves?"

"I'm no expert," the codfish said. "I just dabble in it for the halibut."

"O," the man said. And he sank silently into the sea.

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MSD MILITARY SYSTEMS DESIGN

formerly MILITARY AUTOMATION

VOLUME 3, NUMBER 6
NOVEMBER-DECEMBER 1959

MSD editorial

Defeat by Stretch-out

The November 30, 1959 issue of Time magazine comments on the outlook for the fiscal 1961 defense budget. They significantly report that few U. S. military men believe that the vast $41 billion-plus funds will be spent wisely enough to provide for the best or even adequate defense.

Slow compromise with the fast, uncompromising changes in modern-weapons technology, with the result that funds are spread out too thin over too many half-finished, half-good or plainly outdated programs, is blamed for our failure to concentrate spending on the strict necessities of today and the future.

Examples of the "stretch-out philosophy" which preserves high-sounding goals but postpones operational dates on entire weapons systems until after their obsolescence, are cited:

The Air Force Snark, if promptly completed on schedule three years ago could have filled a gap in U. S. air strength. The first and only Snark wing, put in operation this year after a program expenditure of $740 million, is said to be already ineffective against new Russian defense systems.

The B-58 bomber, originally planned for operation last year, will be further "stretched" with the result that the $2.2 billion spent may never lead to more than 2 or 3 wings, probably obsolescent before they are operational.

The Nike-Zeus anti-missile missile, estimated to need $13.5 billion to become effectively operational, drags along on $300 million year-to-year handouts, getting neither a speedup nor the kill order recommended by its critics.

Another factor is said to be competition between similar weapons developed by different services. Manufacture of both the Jupiter (Army) and Thor (Air Force) ICBM's; also of the Polaris (Navy) and Minutemen (Air Force) solid-propellant missiles, are cited as two instances of compromise in which combined programs could have saved $1.5 billion.

While pointing that in many defense areas increased spending is amply justified—ranging from replacement of the outmoded M-1 rifle to drastic speedups in ICBM and missile programs—Time predicts that the combined effects of stretch-out, overlapping and duplication will continue to buy much less than true value received for our defense dollar.

Although the economic waste resulting from so limber-spined a defense policy is bad enough, when it scuttles the very existence of a dynamic defense for which such projects are initially designed, it is time for leadership to act. We have already slipped to second place in space technology.

EDITORIAL—CONTINUED

BuWeps—Pattern for Administration Policy

In the foregoing article we share a growing concern over the lack of positive defense leadership in the administration. Compromise, indecision and politics-as-usual appear to dictate high level decisions. However, there is some slight indication that improvements may be in sight.

Secretary of Defense Thomas Gates is no newcomer to responsibility in national security. Formerly Undersecretary of the Navy, he has moved through the posts of Secretary of the Navy, and Assistant Secretary of Defense to his present responsibilities. While Secretary of the Navy he initiated a Committee on Organization of the Navy, headed by the Honorable William B. Franke, who succeeded him as SecNav on 1 June 1959.

The Franke Report, submitted only January 31, 1959, recommended a merger of the Ordnance and Aeronautics Bureaus of the Navy Department, because in recent years they had been jointly concerned with a growing and important area of naval missiles. In essence, a duplication within the Navy Department is eliminated by this merger, which was quietly enabled by legislation signed in August, and begun by the establishment of the Bureau of Naval Weapons under RADM Paul D. Stroop on 10 September 1959. A series of physical "desk" moves of former personnel of BuAir and BuOrd offices has since brought together the individuals who will accomplish the mission of BuWeps, with disestablishment of BuOrd and BuAir scheduled by 1 January 1960.

This mission is defined as the "responsibility for the research, development design, test, operating standards, manufacture, procurement, fitting out, storage, distribution, issue, maintenance, alteration, repair, overhaul, material effectiveness, disposition and salvage of all Naval weapons, Navy and Marine Corps aircraft, airborne target drones, photographic and meteorological equipment, astronautic vehicles, and supporting equipment, and all pertinent functions."

The BuWeps organizational structure functionally is basically a horizontal functional organization with a mechanism for vertical program management. This will merge the skills of the two bureaus into operating groups concerned with Research & Development, Material Management, and Field Support. It will provide an efficient management tool for the activities of the new bureau, comprising about 4,400 departmental personnel and more than 200,000 in the field establishment. Its activities will account for about 40% of the Navy budget, and will expend about 70% of the total Research and Development funds available to the Navy.

With all respect due the abilities of former Defense Secretary McElroy, the elevation of a capable career administrator to the top position in the Defense Department, with experience in achieving a significant organizational improvement in the Navy Department, may point the way to a reversal of the wasteful and dangerous policies which are discussed in the foregoing editorial.

Mobile Power System Replaces Rotary Types

A new all-electronic ac power system permitting mobile and multiple purpose useage is said to be rapidly replacing fixed-frequency rotating power generators in laboratory, factory and field applications. The demand for this power system, a development of the Metrolog Corporation, 169 North Halstead Street, Pasadena, California, stems from several engineering and cost considerations. For example, by providing combinations of variable and fixed frequency outputs over a broad range of frequencies, the Metrolog "500" power system (Fig. 1) can fulfill all

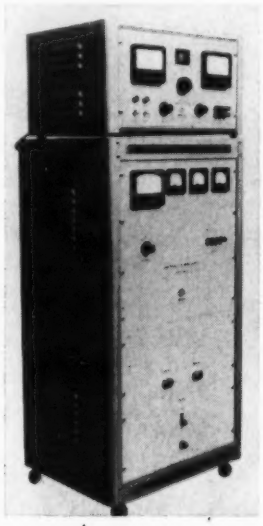


FIG. 1. FIXED OR VARIABLE frequencies are supplied by new "500" series AC Power supply unit in sizes up to 1 KVA/phase for laboratory and field service applications.

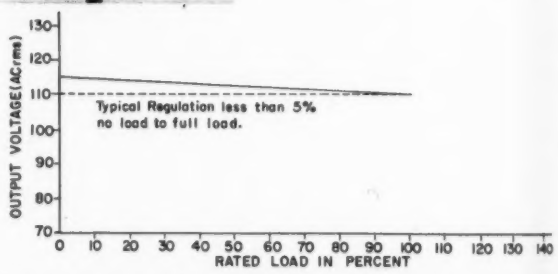


FIG. 2. OUTPUT VOLTAGE vs LOAD characteristic of Metrolog "500" AC Power Supply, typically less than 5% from no-load to full-load, allows fusing normally at 10% over maximum rated power level. An adjustable voltage amplitude control permitting momentary overloads, such as occur when starting induction motors, is a major advantage of the AC type power supply.

present and anticipated future needs where ac power, other than 60 cycle line, is required. Short-term economic advantages are realized since it can be readily moved from one use area to another for immediate operation. Other cost advantages become evident when compared on a dollar-per-watt basis with rotating equipment, and when the limitations imposed by rotating equipment, including the costs of permanent installations, are considered.

Selected by many industrial users for laboratory and field service applications, the characteristics of the Metrolog "500" power systems also are said to make them ideally suited for shipboard and mobile ground system applications, and to have resulted in

their selection for use at missile launching sites.

Typical characteristics of the power systems include ratings ranging in power from 40 va per phase to 1 kva per phase in either single or polyphase outputs. Output voltages are fully adjustable from 0-130 line-to-line on single phase units, 0-130 volts line-to-line on two phase units and either 0-130 line-to-line on three phase delta or 0-130 line-to-neutral on 3 phase wye units.

Output frequencies may be variable or fixed or a combination of both over the ranges of 300 cps to 5.4 kc. Frequency stability is from 0.25% for variable outputs and down to 0.01% for fixed outputs. Waveform is sine wave with less than 3% total harmonic distortion. Load voltage regulation is 5% for variations from no load to full load. Line voltage regulation is 1% for 10 % line change. The systems also incorporate excellent transient response and stability. (Fig. 2).

Circuit design employs the building block concept utilizing standardized circuitry, which permits simple modification of existing production components for a specific application. The over all power system is designed and packaged to provide long trouble-free operation and to facilitate ease in servicing.

FOR MORE INFORMATION CIRCLE 68 ON READER-SERVICE CARD

Compact Office Copier Uses Plain Paper

A new rapid office duplicator using the Xerox electrostatic principles which have been so successful in larger machines for the automatic duplication of engineering drawings from microfilm and other materials, will be available in early 1960 as the XeroX 914 Copier. Occupying no more space than a stenographers desk, using sensitized paper, liquid or gases, it copies material written or typed in any color onto plain white or colored paper. The copied material has sharp permanent black type and lines for as many copies as desired. The operator sets the quantity control and the number of copies are automatically fed out.

The originals may be drawings, letters, magazines or books of any thickness, up to 9″ x 14″ dimensions. Prints can be made on offset masters, card stock or vellum as well as ordinary paper, at a speed of up to six copies per minute.

Principles of the Xerox electrostatic process which are familiar to the readers of MILITARY SYSTEMS DESIGN will be recognized in the schematic diagram of Fig. 2. A reflected image of the original document is focussed on the charged selenium drum. Light striking the clear areas of the drum dissipates the charge except for the darker lines, to which the dry powdered thermo-plastic developer adheres. This plastic material is then transferred electrostatically to an ordinary paper sheet off the supply rack, fused to form unfading black lines or type, and the finished copy is delivered smudgeproof-dry to the receiving tray above.

The XeroX 914 Copier will extend the economies and conveniences of xerographic duplication to smaller firms and may also be used to supplement the larger xerographic machines in Military and other large-scale operations. It is anticipated that it could also assist in relieving clerical bottlenecks at military headquarters and aboard flagships of the fleet.

The new Copier, a product of Haloid Xerox Inc. of Rochester 2, N. Y. will be available to users for lease or sale. Under the leasing plan, there will be a monthly charge of $95 plus a modest charge for each copy made over a minimum. Whether the machine is purchased or leased, the cost of consumable supplies will be about 1-cent a copy.

Said to be the first and only office copier to make copies on ordinary paper, the 914 requires no adjustments of exposure or development. Thus, the first copy is always perfect, even when the copier is operated by inexperienced personnel.

FIG. 1. **DRY PERMANENT** copies on plain paper from black and white or colored originals are quickly produced by desk-sized XeroX 914 Copier.

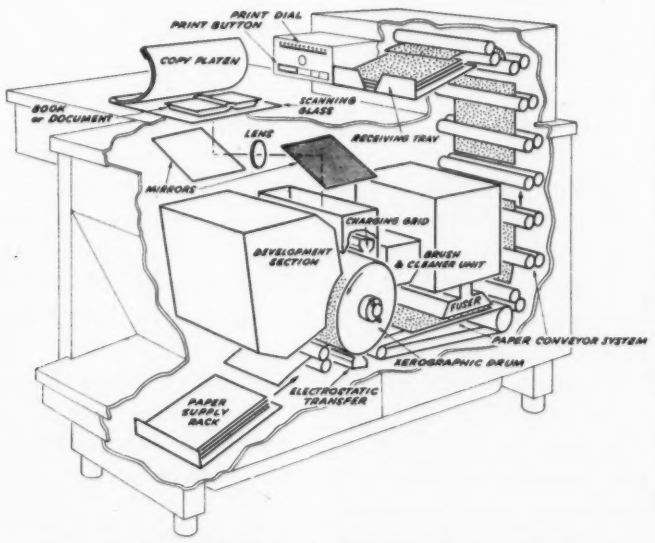


FIG. 2. **OPERATION** of **XEROX** Copier is shown schematically. Xerographic drum deposits thermoplastic letters and lines on plain paper which are permanently fused into a non-fading copy of the original. Operator needs no experience.

FOR MORE INFORMATION CIRCLE 69 ON READER-SERVICE CARD

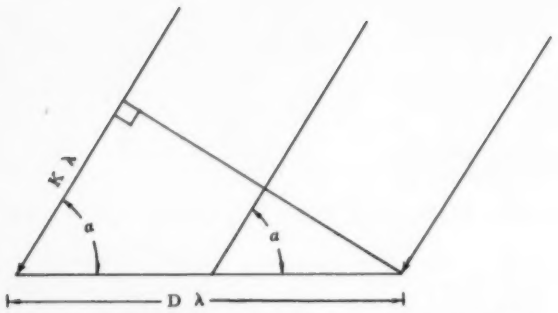


FIG. 1. **INTERFEROMETER** baseline geometry.

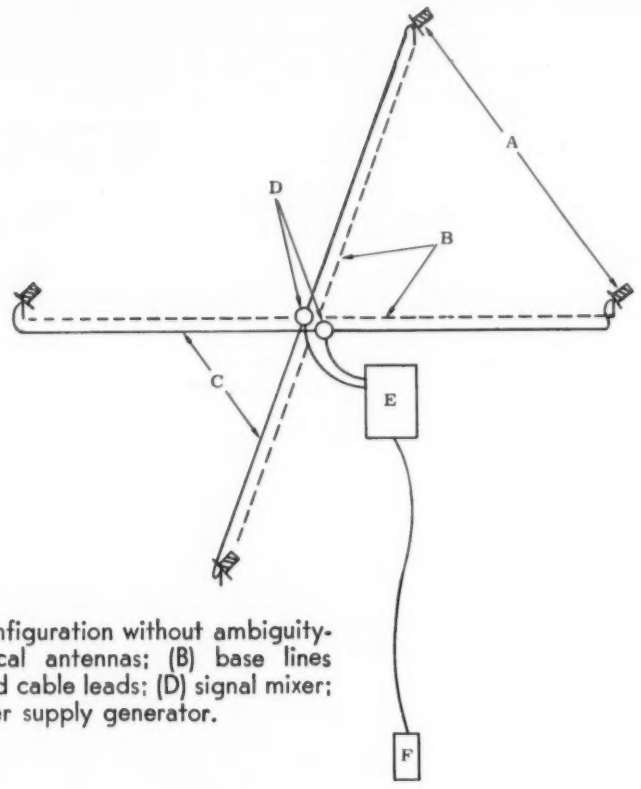


FIG. 2. **MIDOT STATION** Configuration without ambiguity-resolving baselines. (A) Helical antennas; (B) base lines separating antennas; (C) buried cable leads; (D) signal mixer; (E) Instrument trailer; (F) power supply generator.

The MIDOT Missile-Tracking System

T. L. PACE and *T. V. CRAWLEY*, Sandia Corporation

DEVELOPMENT of a tracking system capable of determining the spatial co-ordinates of several ground-launched missile vehicles is described. The problem was complicated by the fact that all of the vehicles would be launched simultaneously, and simultaneous tracking would be required. The volume of uncertainty around each vehicle was not to exceed a spherical radius of 2,000 feet at ranges up to 50 miles.

Preliminary Study

Several electronic systems, such as Radar, Cotar, Microlock, and Minitrack Mark I were investigated and rejected because of prohibitive cost or excessive complexity. The Minitrack Mark II system, a development of the Naval Research Laboratory, is an adaptation and refinement of the interferometer principle that has been used by radio astronomers for many years. Since they have obtained excellent results with only the bare minimum of equipment, it was decided to use this approach to solve the tracking problem.

The Mark II interferometer system has some very desirable advantages and, of course, some disadvantages. Perhaps the most serious disadvantage is that dead spots in the missile antenna will yield false information. Launch angles must be determined in advance to prevent the presentation of ambiguous data. Data reduction is slowed because the first part of the reduction process must be manually performed. Finally, the system is limited to use on vehicles with ballistic trajectories.

It was decided that these disadvantages were more than offset by the very desirable advantages of the system. The Mark II system uses simple, commercially available equipment that is relatively inexpensive even for multiple tracking. It makes use of the telemetering transmitter which is already located in the airborne units, and it will provide data accurate to 100 parts per million of cosine values. In the light of these advantages, it was felt that the Mark II system most nearly fulfilled the stipulated requirements. The particular configuration used by Sandia Corporation was named MIDOT (Multiple Interferometer Determination of Trajectory).

Interferometer Theory

The theory of operation of the simple interferometer may best be understood by referring to Fig. 1. Assuming a parallel wavefront arriving at the ends of an antenna baseline, it can be seen that the following relationship exists:

$$\alpha = \cos^{-1} \frac{K}{D} \qquad (1)$$

where α = angle between the line of sight to the target and the baseline

λ = wavelength of operating frequency

K = constant

D = constant

The output of the two antennas that comprise one baseline is fed into a single summing point (hybrid or T). A null occurs at this summing point whenever a 180-degree phase delay is produced by the difference in the two parallel ray arrival times. In other words, this condition is met when K in Equation 1 is 0.5, 1.5, 2.5, etc. The angles at which a null occurs can then be calculated by using the formula:

$$\alpha_n = \cos^{-1} \frac{(K + \frac{1}{2})}{D} \qquad (2)$$

where α_m = angle at which null occurs

K = 0, 1, 2, 3, 4 .....(D—1).

The values of α_n have been determined from 0° to 90°; the pattern from 90° to 180° is a mirror image about the Y-axis of the data from 90° to 0°.

Since the 100λ baseline is valid for only one frequency, calculations with revised D values are required to determine in similar manner the null points for frequencies that differ from the design frequency.

Information from each baseline gives a direction α from the line, which is a cone (assuming the direction is known within ±90°). Two baselines crossed at right angles give two intersecting cones that define a line in space (Fig 2).

A third baseline located at some distant point would give a third cone. The intersection of the

FIG. 3. **CIRCULARLY POLARIZED** broad-band antenna has characteristics needed for tracking system.

three cones would define a point in space. In practice, it is more feasible to use another crossed baseline station, because the point in space is then defined by two intersecting lines. This procedure simplifies the data reduction process. A minimum of two crossed-baseline stations are required, with a third being very desirable.

Receiving Antenna System

The problem of simultaneously tracking several missiles established the following general requirements for the receiving antennas:

1. Circularly polarized and inherently broad band.
2. A beam width of approximately 70°.
3. Gain to the order of .8 db at the half-power points.
4. Insensitive to multipath.
5. Phase centers must be very nearly equal and must shift equally for various angles to the source.

Helical antennas most nearly meet these requirements and have the additional advantage of being inherently rugged and simple. Fig 3 shows one of the antennas set up at the test site.

Receiver System

Each interferometer antenna baseline produces AM modulated signals consisting of a predictable pattern of nulls generated by the antenna system. The null frequency depends on missile trajectory with respect to receiving station location. The signal also contains an AM modulation component that results from a non-symmetrical transmitting antenna pattern rotating with the missile at its stabilizing spin rate. The signal strength of each of the signals varies between 5 and 1000 microvolts. (In a situation involving the tracking of several objects, two information channels are required from each object at each receiving station, exclusive of any ambiguity resolving baselines which may be required.) A block diagram of the receiver system for one baseline is shown in Fig 4.

Because of the low modulation frequencies expected, drifts in the system oscillators are the controlling factor in the predetection bandwidth. There are three oscillators in each channel: one in the transmitter and two in the dual conversion receiver. The transmitter oscillator and the first local oscillator in the receiver are crystal controlled, and the receiver crystal is temperature regulated. The second local oscillator in the receiver is a highly stable, tunable unit. The receiver bandwidth must be wide enough to prevent the signal from drifting out of the passband. Transmitter specifications permit a drift of ±23 kc. Receiver drift is held to 0.002% of received frequency, which corresponds to a drift of ±5 kc; therefore, the minimum bandwidth of the receiver is 56 kc. For the above application, this bandwidth provides the best signal-to-noise characteristics in the receiver.

A receiver with a 12 db noise figure and a 56-kc bandwidth has an output signal-to-noise ratio of better than 20 db with a 4-microvolt input signal. Although a 20-db signal-to-noise ratio is sufficient, it can readily be improved by the addition of a low-pass filter after detection. With a maximum null frequency of 10 cycles, it should also be possible to reduce the effects of the rotational modulation caused by the non-symmetrical transmitting pattern.

If the stations are to be remotely controlled, the receiving equipment must have a high degree of stability. The use of a temperature-controlled crystal for the first local oscillator, along with a highly stable second local oscillator, will hold the drift to ±0.002 percent of the received frequency. The output circuits of the receivers differ from those of conventional receivers in that DC coupling is required to drive Miller oscillograph galvanometers. If available, low-frequency galvanometers may be used, eliminating the output low-pass filter.

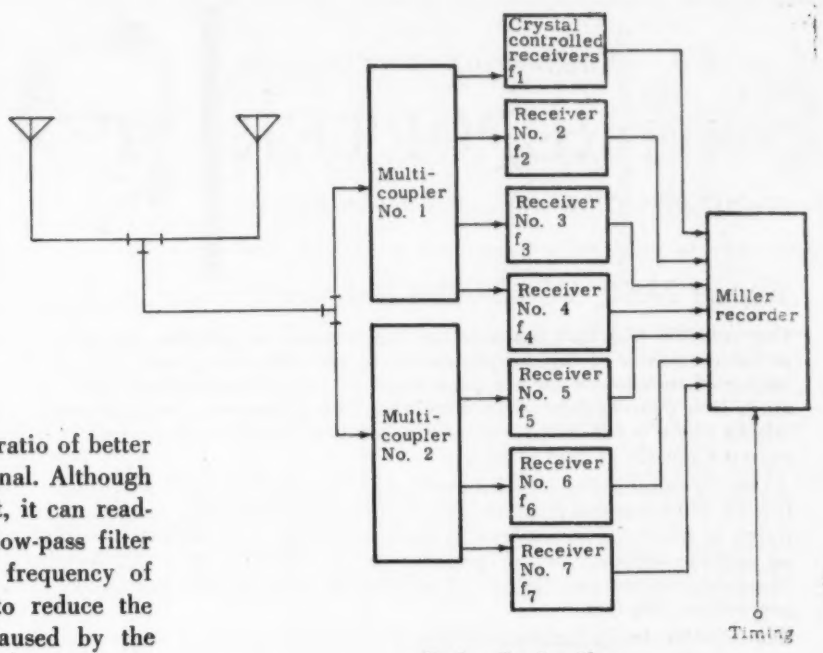


FIG. 4. BLOCK DIAGRAM of receiving system for one MIDOT base line.

Recording System

A minimum of 2 channels per object, plus timing channels, is required for each station. If extra antennas are required to resolve ambiguities, it may be necessary to record 4 channels per object, depending upon the system used. The 10-cycle null rate is recorded at a paper speed of 3¼ inches per second. This speed provides 960 seconds of recording time.

Tests

A MIDOT system consisting of a single baseline was constructed in May, 1957 in order to determine the order of magnitude of the fixed errors. A Beechcraft Bonanza carrying a Bendix telemetering transmitter was tracked by both the MIDOT system and by an Akeley theodolite. It was found that the two systems did not differ by more than ±6 minutes. A ±6-minute angular error to a target with a 250,000-foot slant range at an assumed elevation angle of 45 degrees yields an elevation uncertainty of approximately ±310 feet, which is well within the required accuracy.

Two MIDOT systems (Fig. 5) were installed at the Tonopah, Nevada, Test Range to determine the trajectories of practice missiles fired at intervals between July and November, 1957. Askania theodolite coverage was also available for these firings. A comparison between the MIDOT and the smoothed Askania data showed agreement within a 6-minute maximum.

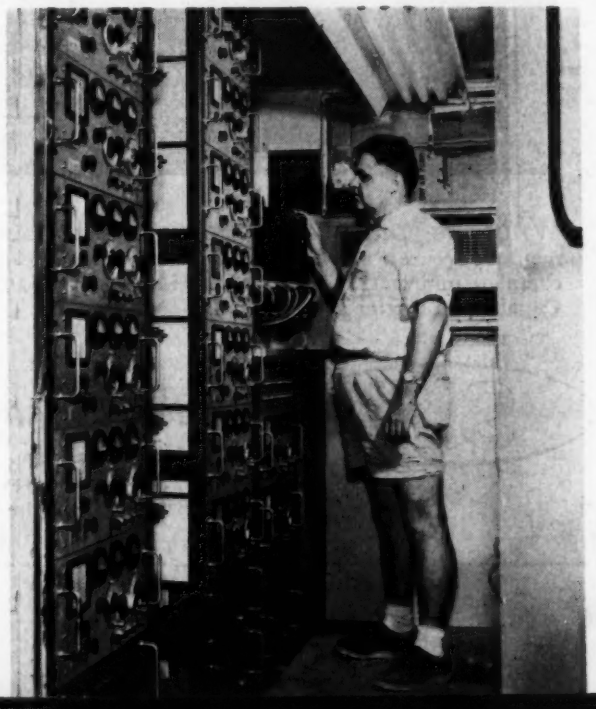
Data Reduction

Data reduction time was at first considered to be almost prohibitive; however, it has since been reduced by a factor of three of four through the inclusion of ambiguity resolving baseline. Reduction of nine rocket flight trajectories recently required an average two-station reduction time per trajectory of 12.2 man-hours.

Conclusion

More than 50 rocket trajectories have been tracked in both single and multiple configurations. Nine trajectories are the maximum number that have been tracked simultaneously. The MIDOT system has produced records worthy of reduction on 36 trajectories; the remainder of the flights were lost because of transmitter or rocket failure. Operational for about 18 months, the MIDOT has proven an extremely reliable system.

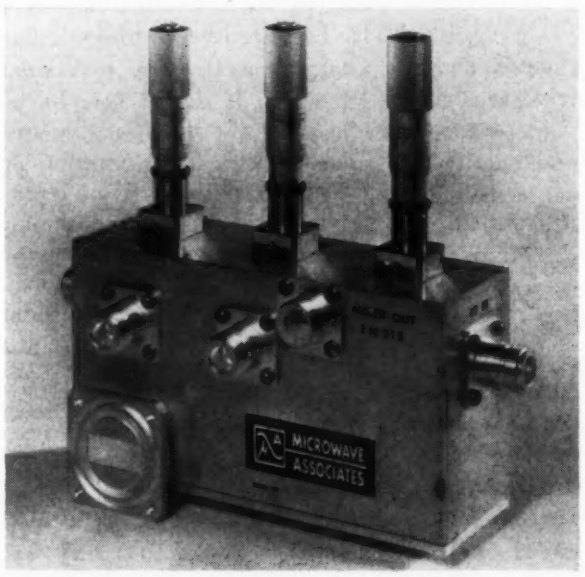
FIG. 5. MIDOT INSTRUMENTATION is contained in a single trailer for each station. Interior view shows some of the receivers and the automatic recorder.



Radar Ranges Improved by New L-Band Parametric Amplifier

Two new parametric amplifier mixer, down-converter units for very low noise reception in the L-band frequencies are now available. Model MA 2-1000, for the 950-1250 mc frequency range, and Model Ma-2-1000L, covering radar frequencies in the 1250-1350 mc range, are developments of Microwave Associates, Inc., Burlington, Mass.

Noise figures below 2 db with bandwidth of 0.25% are claimed for both models. Image rejection is better than 50 db down and dynamic range is 80 db or better, according to Microwave Associates engineers.



PARAMETRIC AMPLIFIER-MIXER/DOWN CONVERTER for use with new or existing radar systems is said to increase reliable ranges from 30% to 50%; couples directly into IF of associated radar receiver.

The amplifiers (see Figure) comprise a single stage of parametric amplification using a suitable Varactor diode; a low-noise mixer, down-converter stage with a 1N21E or MA-421B (1N21F) diode; and a third stage for convenient coupling of the injected local oscillator RF output. Each stage is provided with cavity tuning controlled by precision micrometer adjustments. A calibration chart is provided with each unit.

Radar range improvement figures of from 30% to 50% have been reported as a result of field tests with the amplifier. Although the Varactor parametric amplifier does not achieve the low noise figures theoretically possible with Maser systems, the simplicity of the parametric amplifier and its ability to operate at ambient temperatures without cryogenic auxiliaries make it more practical for military applications.

In addition to the basic Amplifier-Mixer unit illustrated above, a complete MA-2 amplifier consists of a pump oscillator, power supply and waveguide accessories. A BNC type cable couples the mixer output to the IF amplifier stage of the receiver with which the unit is used.

FOR MORE INFORMATION CIRCLE 70 ON READER-SERVICE CARD

Microwave Breadboard Development Aid

New Tri-Plate* Modules which can be assembled in minutes to produce breadboard circuits for microwave development, have been announced by the manufacturer, Sanders Associates, Inc., Nashua, N. H., as the latest development in their compact microwave transmission line and component series. The Tri-Plate* Transmission line is characterized by a central conducting strip sandwiched between two dielectric strips and two shielding or ground strips (Fig. 1). The solid dielectric permits the use of relatively low frequencies; also, high-Q characteristics can be attained.

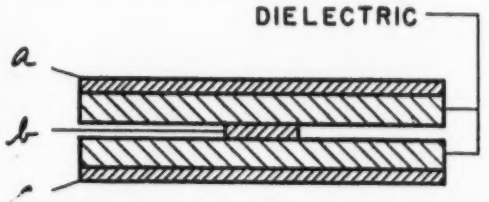


FIG. 1. TRI-PLATE Transmission Line cross-section. Center conductor (b) is equally spaced from grounded conductors (a and c) by two strips of solid dielectric (From "Printed Circuitry" by Allan Lytel, Instruments Publishing Co.)

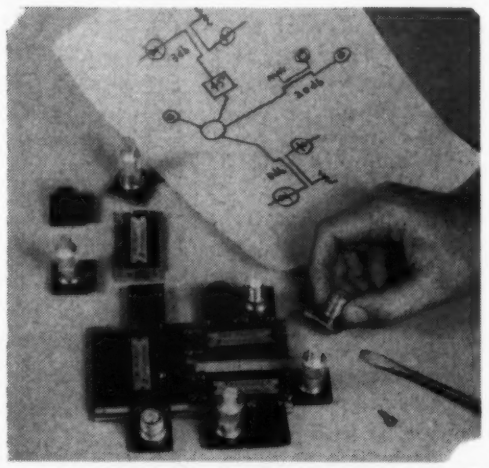


FIG. 2. MODULAR TRI-PLATE building blocks enable laboratory bread-boarding of mixers, duplexers, modulators and other circuits for radar, data link and microwave computer development.

The new modular components include directional couplers, hybrid rings, attenuators, power dividers, bends and special fittings for interconnecting individual units or adapting to coaxial line and crystal mounts (Fig. 2). Line impedance is 50 ohms, standard.

Tri-Plate components are said to offer substantial savings in size and weight over conventional coaxial and waveguide components of equivalent performance. Cross-section of a typical module is approximately ¼" x 1", contrasted with a comparable waveguide (S-band) cross section of 1½" x 3". Additional components which will complete the operating range of the series in higher and lower frequency bands are also being developed.

*Sanders Associates, Inc., Trade Mark.

FOR MORE INFORMATION CIRCLE 71 ON READER-SERVICE CARD

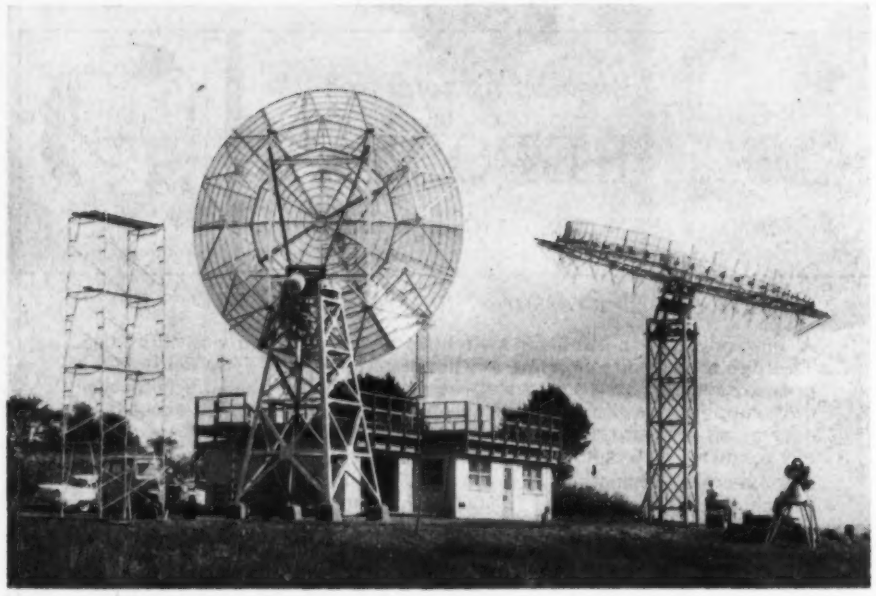


FIG. 1. ANTENNA TEST station overlooking a wide valley faces a distant hill mounting the transmitter station to approximate "free space" conditions necessary for rapid accurate testing of antenna systems.

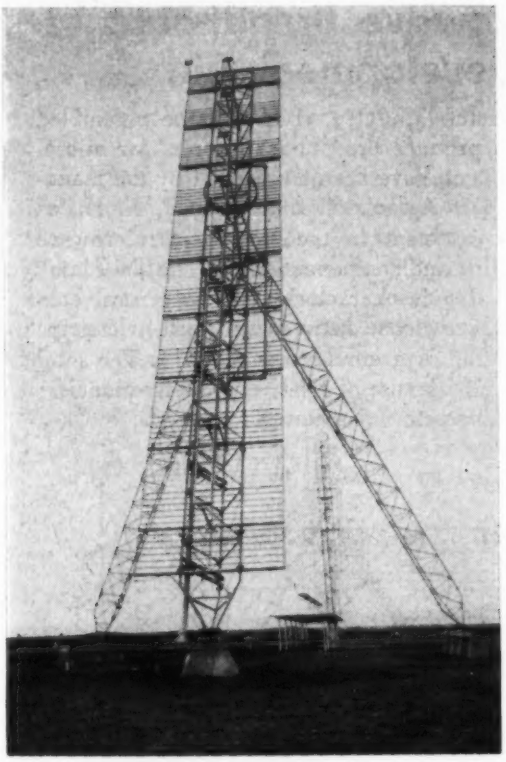


FIG. 2. DOPLOC ANTENNAS for Army's doppler-shift satellite detection and tracking system are a recent TACO accomplishment.

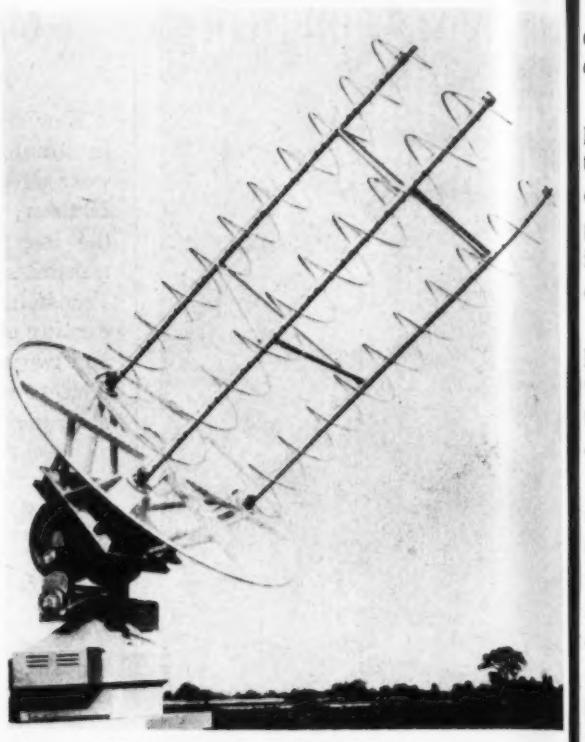


FIG. 3. TRI-HELICAL TELEMETRY antenna is produced in a number of mounting configurations. Electromechanical mount illustrated gives complete remote control with readout in azimuth and elevation.

"Free Space" Test Range Speeds Antenna Design

TODAY'S rapid developments in communications, missile-tracking, telemetering, radar reconnaissance and other military and commercial systems have demanded a corresponding speed-up in techniques of antenna design. Since the antenna is a critical and important part of the overall system, it is also necessary that increasingly exact methods for evaluating the efficiency of a design in both scale-model and full-size prototypes be employed.

Technical Appliance Corporation in Sherburne, N. Y., an organization devoted entirely to design, development and manufacture of various antennas for military and commercial applications, recently opened an advanced "free space" antenna test range to meet these accelerated and more critical requirements. The many considerations given to selection of this facility and the specific capabilities of this particular TACO installation are outlined as an illustration of the entire industry's modern approach to product design.

Antenna design is a unique combination of both mechanical and electrical engineering. The antenna must deliver power in a desired field pattern at certain specified frequencies. Often, the application limits the physical size, while the electrical requirements sharply define the physical tolerances which can be permitted, as well as the rigidity of structure which must be maintained under wind and ice loading.

Beginning with the specified electrical design characteristics, rough physical determinations are electronically established. Weight and mechanical strength calculations are then determined from the known environmental requirements and required safety factors. In many cases, engineering tests during development on full-size prototypes are necessary to establish the final concept.

Both theoretical considerations and practical experience enter into the new-type military and satellite tracking antennas at the new "free space" Technical Appliance Corporation testing range. The range is located a few miles from the main plant at Sherburne, with all facilities to enable all-weather, year-round testing. The test range consists of transmitting and receiving sites on two hills of approximately the same elevation, separated by a 300-ft deep valley. The area is free of obstructions and man-made interference, permitting testing conditions approaching those of "free space". Areas behind both the transmitting and receiving sites are topographically ideal, eliminating secondary reflections of signals.

The test building shown in Fig. 1, dwarfed by antennas undergoing tests, houses the receivers and the latest types of automatic measuring and recording equipment. A transmitter installation across the valley is linked via two-way radio to the receiving site.

At the transmitter site, facilities are provided for the transmission of vertical, horizontal, or circular-polarized signals. Transmitting equipment consists of twelve independent systems, permitting a selection of frequencies throughout the VHF, UHF and microwave bands up to 10Kmc (X-Band). Inasmuch as the distance from the transmitting site to test station, or receiving site is 3000 ft, transmitter power ranges from 250 milliwatts above UHF to 15 watts at VHF simulate operational transmitters having powers up to 5 megawatts.

A wide variety of reflectors and feed systems are available for running tests. These include parabolic and corner reflectors, horns, dipoles, and helical feeds. Transmitters are powered through an electronically regulated supply to precisely maintain predetermined levels throughout a testing period.

At the receiving site, complete erection and mounting facilities allow testing of antennas up to 60 ft in diameter. Electronically controlled mounts are synchronized to automatic measuring and recording equipment in the test site lab. The recorder is syncro controlled from the mount to provide accurate angular data in both azimuth and elevation. Three antennas may be tested at the same time with independ-

ent and simultaneous measurements taken on separate equipments.

Measuring and recording equipment automatically plot the signal strength versus the angular position of the antenna in rectangular co-ordinates. Continuous charts, indicating angular position are plotted to graphically show the directivity. For extreme accuracy in these tests, pen speed is 40″ per second, with a chart positional accuracy of .020″.

Future extension of the TACO test site has been provided for in a projected 10,000-ft range which will triple the present physical size and provide for the testing of larger antennas at still higher frequencies.

The value of a "free-space" test range with its associated automated instrumentation is reflected in shortened lead-time in new antenna design and check-out. One recent TACO development is the DOPLOC antenna (Fig. 2) for tracking orbital bodies, recently engineered under military contracts. This system consists of three antennas at each station for locating and tracking friendly or enemy satellites. Another system meeting modern telemetering needs is a circularly-polarized tri-helical antenna (Fig. 3) employed in receiving data from missiles or satellites. An electro-mechanical mount provides complete remote control with read-out in elevation and azimuth. This unit may be slaved from tracking radars to keep the telemetry antenna axis pointed toward the satellite.

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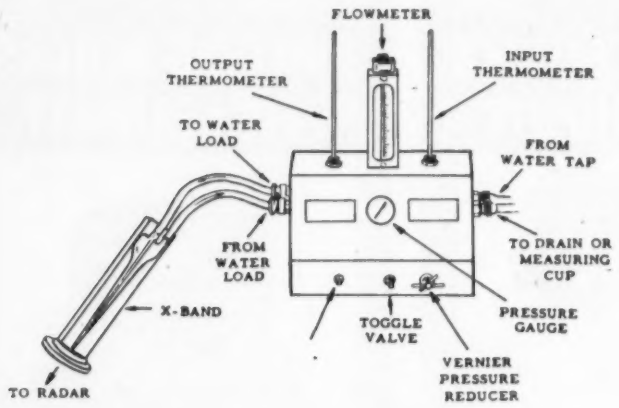


FIG. 1. MICROWAVE CALORIMETER (a) Model SME-18 including typical loads for RF bands from 3900 to 26,000 mc. (b) Labeled diagram of connections.

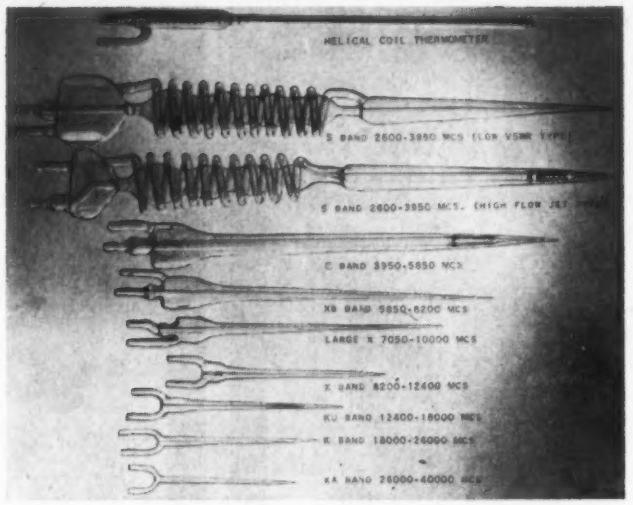


FIG. 2. HELICAL THERMOMETER and Water Loads for use with Microwave Calorimeter.

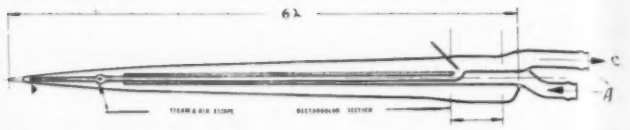


FIG. 3. HIGH POWER Water Load showing (A) water entry, (B) Steam and air relief path, (C) water exit path, and (D) re-entry path for condensed steam.

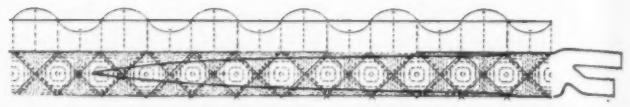


FIG. 4. ABSORPTION OF RF ENERGY by Water Load in waveguide. Load absorbs in sinusoidal manner approximately 90% of power remaining in each half wavelength.

ACCURACY AND SAFETY IN MICROWAVE ENERGY ME

SAMUEL FREEDMAN, **Pres. Chemalloy Electronics Corporation**

THE HAZARDS and problems associated with the measurement of high power microwave transmitter outputs at extremely high frequencies present difficulties which cannot feasibly be resolved with conventional test techniques utilizing circuitry and tubes.

Such conventional methods of power measurement have been found to lead to typical errors totaling 38% or more for reasons such as: Errors in bolometer or thermistor mounts; encrustration in thermocouple elements; reflection errors; absorbed power in connections; dielectric support losses; ohmic losses in metal; element leakage losses; substitution errors; non-linearity of characteristic errors; transfer or calibration errors; and miscellaneous errors due to modes, ratios, transistions, etc.

To eliminate such sources of inaccuracy, particularly in the case of high power Radar or Linear Accelerator equipment where the energy magnitudes require very high ratios for indirect measurement, development of the Microwave Calorimeter using the RF Water Load became necessary. Today, most activities concerned with appreciable RF power measurement between 1,000 and 75,000 mc, and involving average power levels from 1 to 50,000 watts with peak powers up to 1000 times greater, are using the Water Load type of Microwave Calorimeter. This method is capable of extension to still lower and higher frequencies and to very much greater average and peak powers. No maximum limits have been sighted.

Safety Considerations in RF Testing

The Air Force, in a Technical Order dated 17 June 1957, established a maximum power density of 0.01 watts per sq. cm as a permissible safe level for the exposure of maintenance and operating personnel to RF fields. This order also stated that: "dummy water loads or other absorptive materials will be utilized to absorb the energy of high power generators which produce power levels of 0.01 watts/sq cm or more while being operated."

Other conditions in which the Water Load Microwave Calorimeter is preferentially employed are: Where the RF power is so great as to destroy dry or static load media; where a maximum VSWR well below 1.1 is required to avoid damage to costly tubes and other components; where there is need to tune or make adjustments on equipment operating at full power without space radiation; and where operating principles need to be simple, obvious and without mathematical complications.

Principles of Microwave Calorimetry

Calorimeters for radio frequency measurement using the Water Load principle constitute both a precision radio frequency wattmeter and an efficient dummy RF load. It may be known by different use names, such as: Calormetric Wattmeter, when used to measure power in watts; Calorimeter, when power is expressed in calories; a Water Load if the dummy load uses water as its medium; and either a Waveguide or Coaxial Calorimeter depending on the type of load unit which is used. All are essentially the same instrument (Fig. 1).

In each case, it functions as a simple device for circulating selectable known amounts of liquid flow through a suitably designed low-VSWR RF-transparent load. This load is correct for each frequency band for dominant mode operation and has an axial length several times the λ of the energy to be absorbed. If this axial length equals 6λ, a suitably configurated load will have a natural VSWR of 1.03. The load is located in a waveguide or coaxial section mating to the output termination of any RF energy source such as a magnetron, klystron, travelling-wave tube, or any communications transmitter, radar, linear accelerator or other source of RF energy needing to be measured or absorbed harmlessly.

Absorption of the RF energy by the circulating liquid in the load causes the liquid to experience a temperature rise directly related to the flow rate and power involved. The liquid temperature change in °C multiplied by the flow in cubic centimeters/minute computes directly to calories/minute in the case of water, in which the specific heat is 1. Each 14.334 cal/min is equal to one watt of power regardless of frequency. If a liquid other than water is used, the apparent calorie rate count is multiplied by the specific heat of that fluid to obtain the true power. For example, if alcohol, with a specific heat of 0.5 is used, the temperature rise will be twice as much as with water. Table I lists pertinent formulas used in calorimetric RF power measurement. By inverse applications, the same calorimeter and energy source may serve as power standard, flow standard, temperature standard, specific heat standard, etc.

The power measured is an average of all energy components present, whether CW or pulsed. It is independent of the peak, fluctuating, or intermittent energy values existing in a system.

Microwave Calorimeters owe their high accuracy

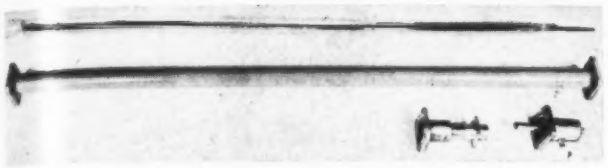


FIG. 5. COAXIAL WATER LOAD uses slightly saline solution to achieve low VSWR at lower frequencies.

TABLE I. FORMULAS AND CONVERSION FACTORS FOR MICROWAVE CALORIMETERS

1. Power (Cal/min) = Flow (cc/min) x ΔT (Temp. rise in °C)
2. Flow (cc/min) = Power (Cal/min)/ΔT (in °C)
3. Power (in watts) = 264.09 V (in gal/min) x ΔT (in °C)
   = 146.72 V (in gal/min) x ΔT (in °F)

CONVERSION FACTORS

1 watt = 14.334 cal/min = 3.414 BTU/hr = 0.05688 BTU/min
1 milliliter = 1 cc = 0.0002642 gal = 1 g or 0.0002205 lbs water (sp. gr. 1).
1 gal water weighs 8.347 lbs or 3785 g @ 4°C.

GY MEASUREMENTS

and efficiency to: Super-sensitive helically-coiled mercury thermometers designed for this use having Dewar flask arrangements, to properly configurated and dimensioned water loads, and to accurate flow determination. Where desired, the flowmeter can be calibrated to read power in watts or calories as well as flow rate. Typical accuracy attained in practice may be between ½% and 2% depending on frequency and power level. At appreciable power levels from a few watts upward, high accuracy can be obtained on any frequency band. Below a few watts of power, the accuracy will be best at the higher frequency bands where load dimensions and liquid volumes are smallest.

The Calorimetric Thermometer

The specialized thermometer (Top Fig. 2) developed for the Microwave Calorimeter program has the following features: (1) The mercury reservoir at the base is a helix of several turns, which permits a more rapid transfer of temperature information from the water passing around it. (2) The Dewar flask enclosement of the helical mercury reservoir constitutes a thermos bottle within a thermos bottle which provides correct water sequence (first water in is first out) and liquid path continuity even at minimal flow. Thermal isolation assures reproducibility of reading while path continuity permits readings down to a minimum power. (3) The slender mercury column is magnified for accurate reading by the presence of a blue colored magnifying mirror behind the capillary tube; facilitating accurate reading in ordinary lighting. (4) the mirror also provides an anti-parallax feature by requiring that the eye be in a certain angle to read the scale, which minimizes reading errors due to differences in individual vision.

The Water Load

The basic configuration of the Water Load is a sharply pointed tip gradually tapering to the full inside dimensions of a waveguide housing in a distance of six axial physical wavelengths. The Low VSWR type coiled load (S band) shown in Fig. 2 has a typical VSWR of 1.03 and an absorption of about 80 db (100,000,000 to 1).

The tremendous power output of Linear Accelerators used in nuclear research is absorbed harmlessly by the Three-path Water Load, shown in Fig. 3. This arrangement can be used when the power levels become great enough to convert the water at the tip to steam.

Since 90% of the power is intercepted in the first half-wavelength from the tip (Fig. 4), at high powers this area tends to form steam. This steam will surge the water and possibly cause the load to explode. This is avoided in the 3-path Water Load where path A brings water into the tip zone, while path B is narrow-diameter relief tube extended into the tip of the tube to give steam forming there a convenient escape path to prevent water surges. Cavity C is a water return path having full diameter of the load envelope to avoid load path resistance or pressure buildup. The steam path B rejoins path C at the far end of the load after it has condensed to water, consequently its temperature information is not lost before reaching the output thermometer.

Another provision for design of high-capacity loads is to off-center the load tip in the waveguide housing with a Teflon* support spacer so it is spotted about midway between counter and wall of the waveguide. Then the tip of the load absorbs less than 90% of the power with succeeding half-wavelengths absorbing proportionately more in load zones where taper diameter and liquid volume are greater.

Pressurized load-waveguide combinations are available for conditions of very high peak power, where pressurization of the waveguide is necessary to avoid arc-over.

Coaxial load design (Fig. 5) requires somewhat different treatment, otherwise the longer wavelengths involved would require excessively long loads to achieve the six half-wavelengths required to provide low VSWR. The VSWR of the illustrated load at 1000 mc will be about 1.2 when water is the cooling medium, but will increase to about 8.00 at 250 mc. However, if a solution of 2 tablespoons of table salt in 3 gallons of water is used, the VSWR will drop to less than 1.1 even down to 50 mc. It then behaves as if it were electrically many times longer, showing the effect of wavelength shortening by a factor equivalent to the square root of the dielectric constant of water (K for water is about 81). A standard reservoir-cooling unit to permit conservation of saline solutions or other liquids used for Microwave Calorimeter cooling is available.

*Teflon is TM of DuPont

Correction for Specific Heat Variation

Whenever liquids other than pure water are used in a water load a correction for deviation of specific heat from the distilled-water value of 1.000 is necessary. The Calorimeter may readily be used to ascertain the true value of specific heat of an unknown quality liquid, such as tap water. One first takes a calorie count against a stable energy source using distilled water—assume for example, 10 watts computes to 143 cal/min. Then measure the same power with the tap water as coolant and again compute the power using assumed specific heat of 1.

Other Corrections

The VSWR of a load can be checked by filling it with water and using it to terminate a standard VSWR Impedance-Measuring slotted line. If sharply configurated and 6 wavelengths long, it will measure 1.03. Since this corresponds to a reflection loss or lower temperature reading of approximately ¼%, it will be seen that when normal tap water is used the specific heat and reflection-loss errors tend to cancel each other.

The flowmeter of the Calorimeter has a moving float, subject to an error of ±2%. Direct measurement of the flow by use of a measuring cup is recommended whenever higher accuracy is essential.

Because every precaution during manufacture is used to exactly match the characteristics of the two highly accurate thermometers, it is believed that any thermometer errors due to aging will be in the same direction, resulting in an unchanged differential temperature, which is the only concern for calorimetric accuracy. The calibration and reading error for the Helical Coil Thermometer is expected to not exceed ±0.1%.

Cooling of the water while it flows from the load to the output thermometer of the calorimeter can be minimized by working with a relatively high flow of water and a low temperature differential. Accuracies to 2% should be assured by this method. If greater accuracy is desired, the theoretical temperature differential rate at zero flow rate can be found by linearly projecting the graph of power vs ΔT readings taken at two or more flow rates.

Microwave Calorimeters and RF Water loads as described in this article are now widely used in the United States, Canada, Australia and Japan, to name a few countries. They render an unique and valuable service as Primary Standards, Secondary or Transfer Standards, for quality control and functional test in manufacturing, maintenance and training activities. The author is indebted to the staff of Chemalloy Electronics Corp., Santee, Calif., and to their working affiliate, the Kahl Scientific Instr. Co., for the information contained in this article.

Selecting a Delay Line

H. WERNICK, F. W. Sickles Division General Instrument Corp.

IT IS the purpose of this article to offer guide points in the selection of delay lines and to indicate the possible mechanical shapes and sizes of a few types.

Of the various kinds of delay lines, the electromagnetic type is the most popular for a varity of reasons. They are simple to use in that the signals that come through them are relatively unchanged in size or shape. Other classifications include the ultrasonic and magnetrostrictive delay types. In ultrasonic lines the information is usually put on a carrier and later must be detected out; the whole process involving serious attenuation. In magnetostrictive lines, in addition to a similar serious attenuator in the signal, the information is differentiated in going through the line and must often be reintegrated to obtain useable wave shapes.

Ultrasonic lines have the advantage of wide bandwidths, making possible combinations of long time delay with very fast risetimes which are not likely to be matched by either electromagnetic or magnetrostrictive lines. The maximum advantage of magnetostrictive lines lies in the ease of adjustment of time delay, together with opportunities for multiple taps throughout the line. Both of these types are likely to be costly as compared to the more economical electromagnetic delay lines.

Within the classification of electromagnetic delay lines, a choice is again offered. Electromagnetic delay lines may be either of a distributed constant type or the lumped constant type. Before going into the details of selection between these types some explanation of their basic characteristics is in order.

Electromagnetic delay lines are artificial transmission lines in which the characteristics of the transmission lines are duplicated in a very small package. The characteristics of a transmission line involve characteristic impedance and attenuation. These characteristics are brought about by the distributed inductance of the transmission line and its capacity to ground, as well as the resistance of the line and its leakage to ground. These characteristics are duplicated quite exactly in a distributed line which also has distributed inductance and capacity and the associated resistance and leakage. In the lumped lines the situation is slightly different in that the inductance instead of being distributed throughout is made up of a number of individual coils which, in general, duplicate the total inductance, together with a number of individual condensers which, in total, generally duplicate the distributed capacity of a real transmission line. If these individual inductances and capacities are used in a great multiplicity the effect is to simulate the distributed characteristics of the transmission line. Circuitwise the lumped constant delay line is identical to a low pass filter (Fig. 1). If an insufficient number of sections are used, it will be found that the cut-off frequency of the lumped constant line is low, so that the band width is restricted and poor risetimes are obtained.

One problem is electromagnetic delay lines which is not so likely to arise in a real transmission line, is that the time delay in the artificial lines is apt to plained in the case of the distributed constant line vary with frequency. This problem is most easily ex- (Fig. 2).

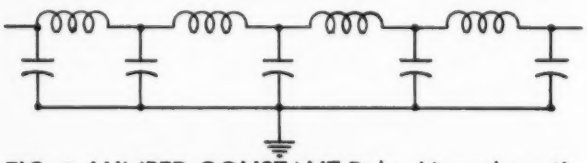


FIG. 1. LUMPED CONSTANT Delay Line schematic is similar to that of a low-pass filter.

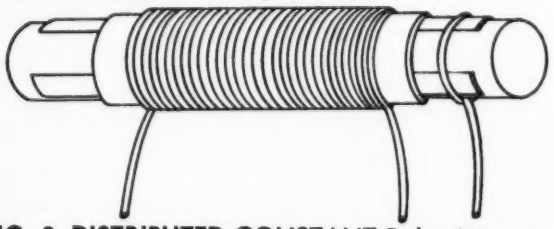


FIG. 2. DISTRIBUTED CONSTANT Delay Line construction uses conductive strips running down length of form as a ground plane, insulated from the winding by a dielectric film.

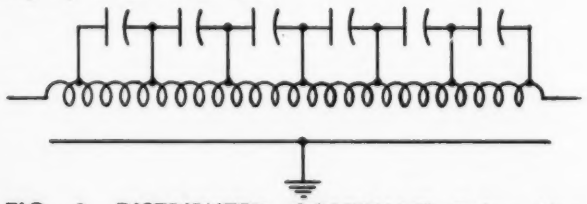
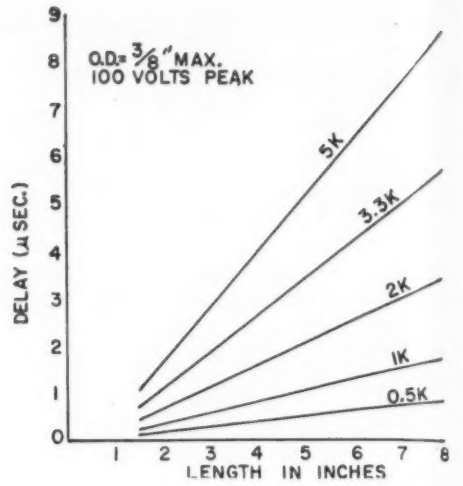


FIG. 3. DISTRIBUTED CONSTANT Delay Line Schematic showing turn-to-turn capacitors for frequency compensation.



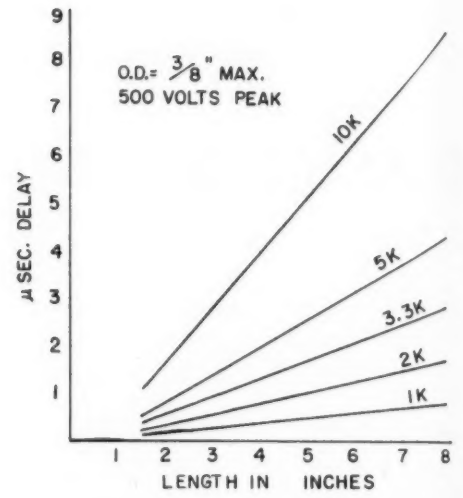
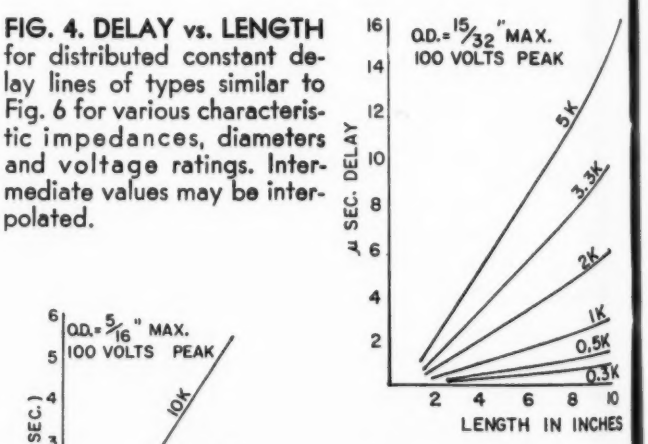
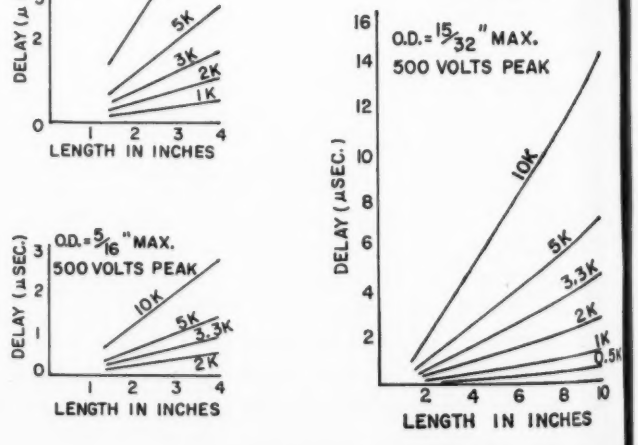


FIG. 4. DELAY vs. LENGTH for distributed constant delay lines of types similar to Fig. 6 for various characteristic impedances, diameters and voltage ratings. Intermediate values may be interpolated.





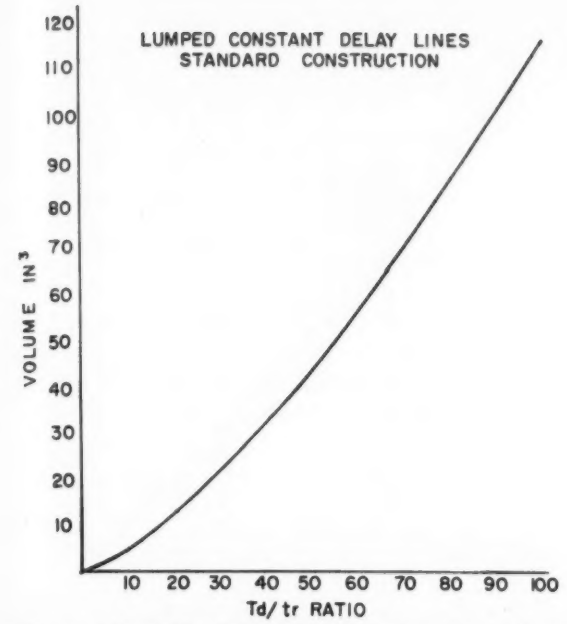


FIG. 5. LUMPED CONSTANT Delay line volume is related to time-delay to rise-time ratio. Curve shows volumes for standard construction suitable for up to about 100 usec. Miniaturized versions may bring volumes down to as little as one-half standard volume.

FIG. 6. TYPICAL DISTRIBUTED CONSTANT Delay line. For dimensions see charts, Fig. 4.

FIG. 7. A TYPICAL LUMPED CONSTANT Delay Line in hermetically sealed shield. Shapes can assume any convenient shape provided required volume as shown in Fig. 5. is allowed.

A distributed constant line is usually made by winding a coil in close proximity to a ground plane so that there will be capacity from every turn of the coil to the ground plane. This then satisfies the condition where there is inductance distributed throughout the length of the wire, and capacity, again distributed throughout. If a low frequency is introduced into the delay line, the direction and amplitude of the current flowing through all the turns of the coil will be the same, with the common magnetic field producing a large value of inductance. If the frequency is increased sufficiently, we will eventually come to the point where, because of the delay in the line, there is reversal of direction of the current in the turns. In some part at least, there will be a bucking of magnetic fields, reducing inductance. Since the time delay is dependent on inductance ($T_d = \sqrt{LC}$) this loss of inductance will result in a shorter delay time. One method minimizing this variation in time delay is to wind the coil in a long, thin form having the coil progress continuously from one end to the other end of the form. When this is done, the coupling between turns having a different phase relationship will be reduced, so that the bucking effect will no longer be so important. The ratio of length to diameter is therefore very important in determining the quality of a distributed constant delay line.

Even after a distributed constant line is made as long and thin as practical, the variation in time delay with frequency may be still great enough during pulse transmission to allow various frequency components of the pulse wave front to come through the delay line with sufficient phase variation to effect the rise time adversely. In order to eliminate this time delay variation, compensating capacity may be introduced into the winding in such a manner as to increase the high frequency delay time. (Fig. 3). A careful adjustment of this compensating capacity, this being a turn-to-turn capacity rather than a turn-to-ground capacity, will result in a time delay which is substantially constant over the usable frequency range of the delay line. It will be noted that schematically this turn-to-turn distributed capacity is identical with a parallel tuned circuit, which would offer high impedance to the passage of higher frequencies. It can be seen that an introduction of this type of compensation will reduce the band width of the delay line.

Lumped constant lines work best when there is some coupling between adjacent sections. As in the case of the distributed constant lines, there is again a possibility for time delay variations with frequency. This is best controlled by adjustment of the coupling between sections, or by the use of bridging condensers.

In addition to having the risetime characteristic spoiled by out-of-phase components in the pulse wave shape, other trouble may be introduced by excessive attenuation of the high frequency components. These may be minimized by designing adequate "Q" into the delay line. On the other hand, excessive "Q" leads to a condition of ringing, and is usually the case when transients are introduced into any high-Q circuit. In turn, ringing may be controlled by using special corrective networks.

Several considerations enter into any choice between the distributed constant and the lumped constant types. Distributed constant type lines are generally lower in cost than the lumped constant type after the careful adjustment of the compensating capacity has been made. This adjustment, however, is such a costly and tedious operation that it usually will not overcome the lower set-up costs involved in lumped constant lines unless a considerable number are made.

The second factor in the choice of line is in the size and shape. Distributed lines are likely to be smaller in volume than lumped lines, but must be shaped in awkward long and thin configurations. The lumped lines, while they are somewhat bigger, can be made up in a wide variety of shapes so that they may often fit in a place where the smaller but longer distributed lines will not. Note the accompanying charts (Fig. 4) which indicate the sizes of typical distributed constant lines and the volume of lumped lines. Note that the sizes shown for lumped lines are for a standard type of construction. A special miniaturized construction is possible which can cut the volume to approximately one-half.

The most potent factor, however, in the choice between the distributed and lumped constant lines must be made in terms of electrical characteristics. The distributed constant lines are practical for higher impedances from about 300 ohms to 10,000 ohms or more, while lumped constant lines can be made easily in impedances starting from 25 ohms and encounter only minor difficulties in reaching the 10,000 ohm end of the scale. Even within the range of 300 to 1000 ohms distributed lines encounter sufficient difficulties so that frequently they are no smaller than equivalent lumped lines, and may even be as costly.

An even more important electrical factor is the ratio of time delay to risetime. This factor in itself often determines the entire construction of any delay line. For practical shapes of distributed lines the customary limit for this ratio is 10 or less. For ratios higher than 10 the line must be made so long and thin as to be quite impractical. In attempting to avoid this awkward shape by the use of multiple sticks, it will usually be found that the cost and size has increased to the point that there is no particular advantage over the more adaptable lumped constant lines.

On the other hand lumped constant lines can be made with delay-to-rise-time ratios as high as 100 or more. As described above this ratio is dependent on such factors as the number of sections used and the high-frequency "Q" of the circuit. The complexity and cost increases at a rate which is considerably faster than the increase in delay to risetime ratio.

Summary

Distributed constant delay lines are more economical than the lumped constant type provided all of the following five conditions apply:

1. The impedance is equal to or greater than 1000 ohms.
2. The delay lines are to be made in quantity.
3. The long thin shape of the distributed lines can be used without handicap.
4. The delay to risetime ratio is no greater than 10.
5. The absolute value of the delay time is within the limits shown in the curves.

Lumped constant lines are required if any of the three following conditions apply:

1. If the impedance is low.
2. If the delay to rise time ratio is greater than 20.
3. If the delay time is large.

In those cases where the type of line is not clearly indicated by the above rules both types should be considered.

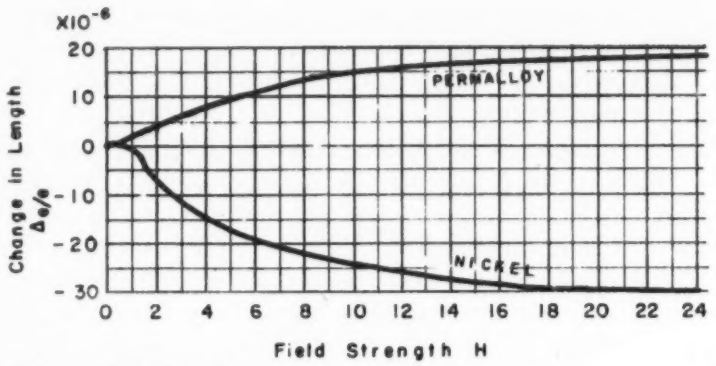


FIG. 1. PERMALLOY expands, nickel contracts with increasing magnetic field strength.

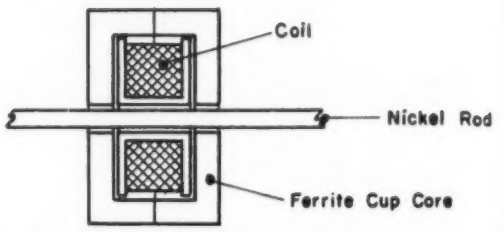


FIG. 2. LAUNCHING and pickup coils are close coupled to nickel or nickel-alloy rod.

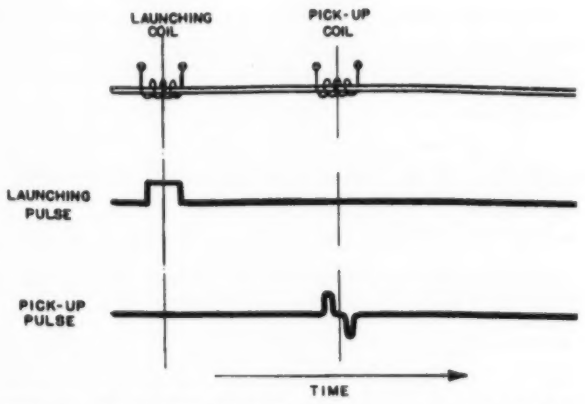


FIG. 3. SQUARE INPUT pulse waveform is differentiated in delayed output pulse.

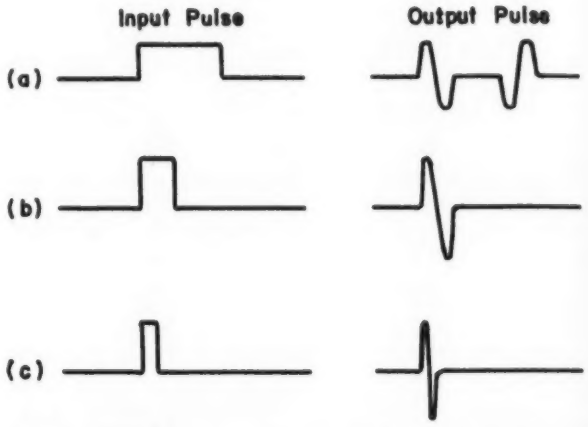


FIG. 4. EFFECT on output pulse from shorter input pulses.

Magnetostrictive Delay Lines

ALBERT POWELL, Vice-Pres., Director of Engineering Deltime, Inc.

Magnetostrictive delay lines have several advantages. Unlike the quartz or glass ultrasonic delay line, the pickup coils can be shifted in position to change the delay; unlike the mercury delay line, the acoustic path need not be a straight line.

MAGNETOSTRICTION is the property of some materials to change length when placed in a magnetic field. The effect may be either positive or negative (Fig. 1); Permalloy has a positive magnetostriction; nickel has a still greater but negative magnetostriction.

The domain theory states that in a material exhibiting magnetostriction, tension will tend to align the domains parallel to the direction of tension. A magnetic field applied to a material such as nickel will rotate the individual domains into the direction of easy magnetization with a consequent shortening of length. When all domains have been oriented in the same direction, the material becomes saturated and no further change occurs. The change in length is propagated as a shock wave at the speed of sound in the

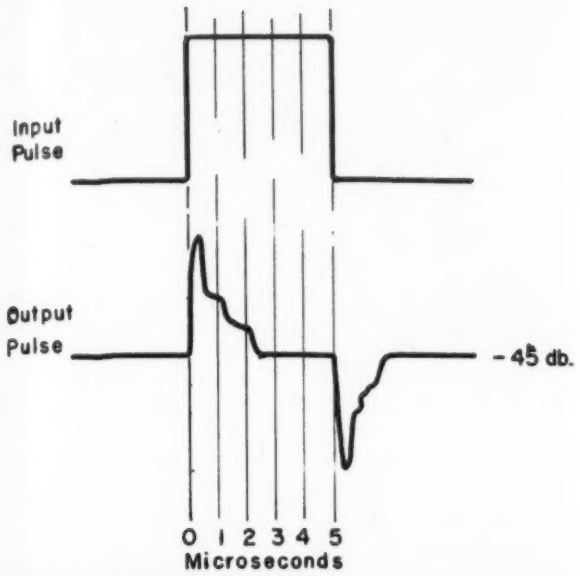


FIG. 5. SHARP RISE and fall of output after 30-μsec delay from 0.5 μsec input pulse.

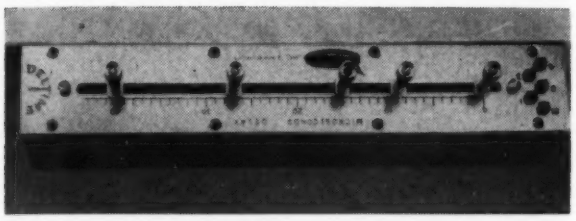


FIG. 6. TYPICAL DELAY line using magnetostriction shows multiple, adjustable delay pickups.

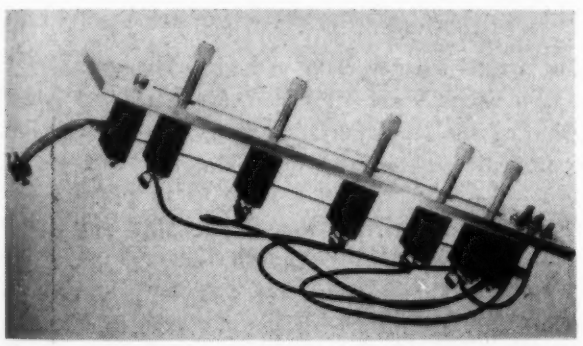


FIG. 7. DELAY LINE exposed showing ends in grease sacks to reduce reflections.

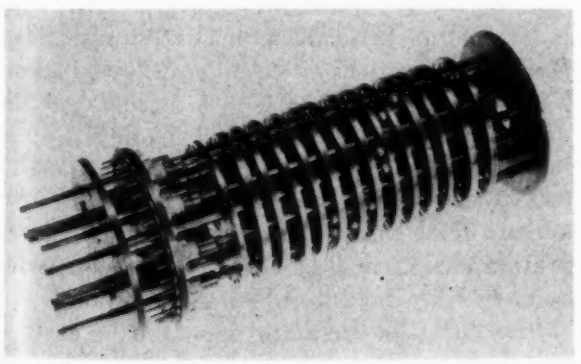


FIG. 8. 1.5-LB DELAY line for aircraft use has 15 pickups whose position can be trimmed from outside after hermetic sealing.

material used. The velocity of propagation of sound in a material is $V = \sqrt{e/p}$ where e is Young's modulus for the material, and p the density of material.

For pure nickel the velocity of sound is 15,000′/sec. which results in a time delay of 63.24 microseconds per foot (length) of nickel. This is a sizable factor of delay per unit length, and proves useful for delay lines.

The initial shock wave (due to the changing magnetic field at the launching point) is propagated in both directions away from the point of impingement of the magnetic field. When the acoustic waves arrive at the ends of the nickel rod, they are reflected completely. Standing waves are thereby set up in the rod, and for useful work it is necessary to dampen out the unwanted reflections. This is accomplished by (1) clamping the ends of the rod between rubber bands, (2) soldering a large blob of lead at the ends, or (3) damping with grease or other suitable means so that reflections are reduced to a negligible value.

The output signal from the nickel rod can be increased by increasing its cross-section area. This ultimately leads to decreasing output when the wavelength of the shock wave approaches the dimensions of the cross section because multiple internal reflections then cause dispersion. Thus short pulses limit the cross section of the rod. The advantage of a large cross section can be retained by using a bundle of small wires excited in parallel. For high frequencies, nickel wire of small cross section is required. For instance, fifty parallel wires No. 38 AWG have been employed for pulses of the order of 1 microsecond.

Launching and Pickup Coils

In order to produce the flux required in the nickel to obtain the maximum magnetostrictive effect close coupling between the coil and nickel rod is essential. In addition, the reluctance of the flux path should be as low as is practicable. To achieve this requirement, the nickel is made part of the magnetic path. Ferrite cores are used to further reduce the reluctance of the magnetic circuit as shown in Fig. 2.

Similar considerations govern the design of the pickup coil to minimize any leakage flux not traversing the nickel. In addition, a small permanent magnet, or the magnetic field of a current-carrying coil must provide the flux which the advancing shock wave is to cut.

Delay Line Operation

As the compression wave in the nickel passes the local flux in the region of the pickup coil, a pulse is generated in that pickup coil by the changing flux. As the tail end of the compression wave leaves the coil area another pulse is generated in the pickup coil, but since the relative motion between flux and rod is now reversed, the coil pulse is in the opposite direction. The received pulse is thus differentiated (Fig. 3).

As the length of the input pulse is reduced, the starting and trailing pulses gradually merge (Fig. 4).

Several techniques are available to generate narrow pulses—the width of the launching coil can be narrowed; high-frequency core materials can be used; dimensions of pickup and launching coils can be reduced; the diameter of the nickel wire can be reduced and the number of wires in the nickel bundle also can be reduced. By such means it is possible to transmit pulses as short as 0.5 microsecond duration. An oscillogram of conditions existing in the transmission of a 0.5 microsecond pulse delayed 30 microseconds is shown in Fig. 5; note the excellent rise and fall time in the delayed pulse.

A delay line showing the practical application of the foregoing-outlined principles is shown in Figs. 6 and 7, showing the external and internal aspects of a magnetostrictive delay line which provides adjustable delay settings up to 42 microseconds.

Another type of delay line developed for aviation use is shown in Fig. 8. In this model a number of precisely spaced pulses are generated from a single pulse and fed into a crystal matrix. A pulse code is obtained by suitably biasing the individual crystals. Fifteen pickup coils are positioned precisely by micrometer screws. The resulting pulses have stability of position in time to within 0.05 microsecond.

Environmental Considerations

As nickel oxidizes gradually in a moist atmosphere, it is desirable to use hermetic sealing, especially for tropical condition.

Nickel has a positive temperature coefficient of delay of approximately 100 ppm/°C requiring the assembly be temperature-stabilized. An unstabilized nickel line will change about 0.5 microsecond per 100 microseconds over a 20° C temperature range. A simple thermostatically-controlled heating system can reduce such drifting to any required tolerance. Alloys are available which have a very low temperature coefficient of delay, less than 5 ppm/°C over the usual temperature ranges required by military devices.

The bundle of nickel wires is under tension and is self-damped against vibration. Vibration does not affect the delay characteristics of the line adversely because vibration is in a transverse mode while the coils are sensitive only to longitudinal waves. However, because of the possibility of mechanical failure of the bundle of wires due to fatigue, some slight restraint against transverse vibration is desirable.

Conclusion

The magnetostrictive type of delay line is rugged. It also (1) has short rise- and fall-time. (2) is infinitely variable within the total available delay, (3) is compact and light in weight, and (4) costs less than comparable delays of other types. It is available as a separate unit for use in the lab, plant, classroom, or field, or as a built-in unit for system or subsystem applications.

THORIUM-TUNGSTEN CERMET CATHODE

J. P. SACKINGER and *R. J. FOREMAN*

Thorium-tungsten cermet cathodes as used in the Westinghouse 6249A magnetron (Fig. 1) offer features which greatly enhance the tube's performance and reliability. Fabrication techniques used by the Westinghouse Tube Division, Elmira, N. Y. in processing such cathodes for over 10,000 Type 6249A magnetism are given.

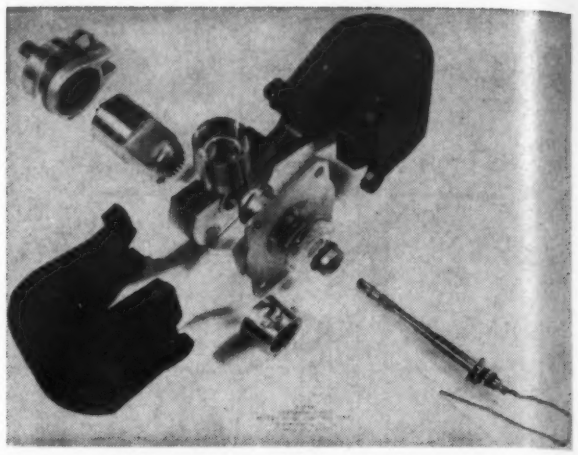


FIG. 1. EXPLODED VIEW of Magnetron WL-6249A, showing cathode assembly. Arrow points to cathode cermet.

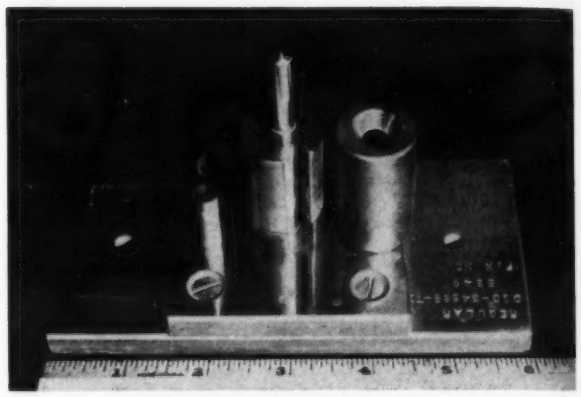


FIG. 2. HARDENED STEEL Cermet pressing die.

Requirements of Magnetron Cathode Design

HIGH POWER magnetron designs are limited in performance and life principally by the cathode material used. Cathode requirements for high power magnetron application include:

1. High primary and secondary emission.
2. Low evaporation.
3. Low gas evolution.
4. Stable geometry.
5. Long life.
6. Rugged surface to withstand arcing and ion bombardment.
7. Good electrical and thermal conductivity.
8. Ability to withstand, without too much deterioration, the normal processing during manufacture of the tube.

No single cathode design has been found to fulfill completely all the foregoing requirements. Of recent interest is the thorium-tungsten cermet cathode[1] which displays certain desirable features over the commonly-used thoria cermet.

Thorium-Tungsten vs Thoria Cermets

In the comparison of the thorium-tungsten cermet and the common thoria cermet there are at least four properties which are characteristic of both cathodes:

1. Both have been used successfully at very long pulse lengths (10 μsec at 8 megawatts peak power levels) in an L-band magnetron.
2. Adequate secondary emission is available from either type cathode for use in magnetrons.
3. Both are relatively stable during mounting operations although a few extra precautions are advisable with the thorium-tungsten type.
4. The characteristically rugged surface of the refractory-type cathode minimizes damage due to ion bombardment.

Advantages observed during magnetron operation of the thorium-tungsten cermet over the common thoria cermet cathode;

1. Tube stability markedly improved.
2. Longer life due to its very low evaporation rate.
3. Complete freedom from geometric change throughout its life.
4. Less sensitive to temperature change, operates from 1200°C to 1600°C.
5. Seasoning-in before tube is installed in a system is not necessary.
6. Greatly reduced leakage current, resulting in more available R.F. power and therefore improved tube efficiency.
7. Excellent electrical and thermal conductivity.
8. Higher primary emission.

Advantages in tube manufacture gained when the thorium tungsten cermet is used are:

1. No activation necessary for emission.
2. Very low gas evolution.
3. High-level factory seasoning of the magnetron can be achieved safely without undue leakage current, thus obtaining the ultimate in finished tube stability.
4. Low radioactivity.

The primary *disadvantage* in the use of thorium-tungsten cermets is that this type of cathode is sensitive to temporary poisoning from oxidation. At room temperature the cathode is stable; however, oxidation poisoning will occur during normal processing unless a protective atmosphere of pure dry hydrogen or inert gas is used whenever the cathode is heated.

Grinding is most critical in this respect. Successful grinding can be achieved using a diamond wheel and a protective atmosphere or collant.

Composition and Processing the Thorium-tungsten Cermet

Initially, fine tungsten powder is presintered at about 1800°C in dry hydrogen, re-crushed and sieved. This is done to agglomerate the smaller particles for better pressing characteristics. At the same time most of the volatile impurities are evaporated. (The tungsten powder is mixed with ditungsten carbide and thorium hydride by tumbling in a dry nitrogen atmosphere. The proportions by weight are 89½% tungsten, 10% ditungsten carbide, and ½% thorium hydride.)

To obtain fresh, unoxidized thorium hydride, thorium powder is fired in dry hydrogen at 800° to 1000° C and slowly cooled. To decrease the pyrophoricity of the hydride it is flushed with inert gas befor air exposure. The flushing time depends on particle size and oxygen content of the initial thorium.

These mixed powders are pressed in a hardened steel die (Fig. 2), using a painted-on die lubricant consisting of a saturated benzene solution of "Sterotex." The green (unsintered) cernet is first pre-

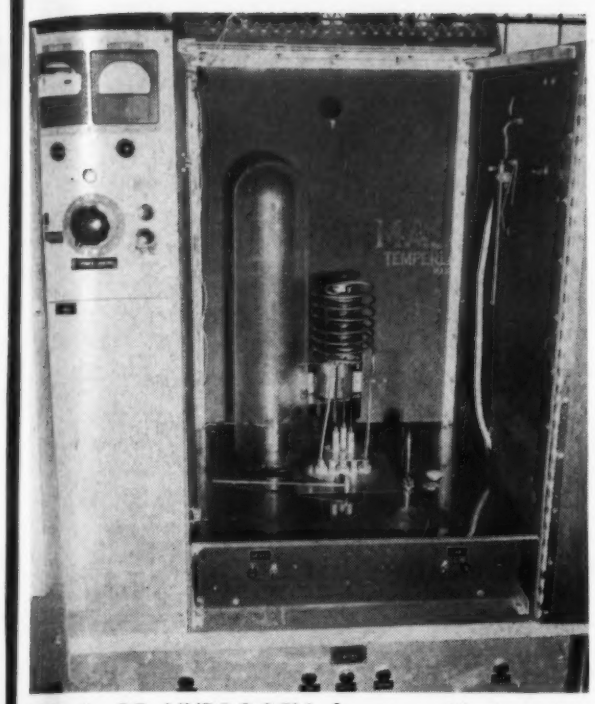


FIG. 3. **RF HYDROGEN** furnace with tungsten heating cylinder and fixtures.

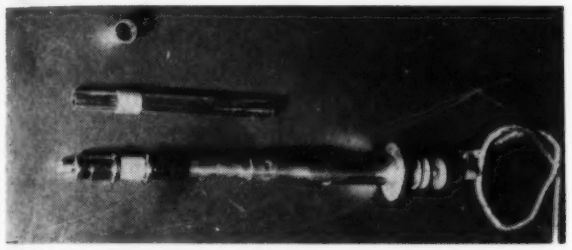


FIG. 4. **SINTERED CERMET,** brazed cermet, and completed cathode-heater structure.

sintered to remove the lubricant and to shrink the cermet a fixed amount. It is then sintered at a temperature of 2400° C using gradual heating and cooling.

All of the sintering and firing is done in an RF furnace as shown in Fig. 3. The double-wound coil has been found necessary to lower voltage gradients between turns to minimize arcing. The RF power source is a ½ megacycle 20 KW generator. The hydrogen used for firing and the inert gas for flushing are dried by passage through a liquid nitrogen trap. Previous to this the hydrogen has been deoxidized and dried in a Baker Deoxo unit.

To withstand the sintering temperature it is necessary to make all fixtures of tungsten. The tungsten heating cylinder and the fixtures used to obtain correct geometry of the cermets are shown in the lower right section of Fig. 3.

The cermet is slipped over a slightly tapered pin about a quarter of an inch in diameter. When the cermet is sintered it shrinks in diameter until constrained and then continues to shrink in length. After cooling, the pin taper aids in removal of the cermet. Accurate length is obtained by diamond honing the ends after sintering. A finished cermet is shown on the left in Fig. 4.

Continued on page 312

This cermet is brazed in the same RF furnace to a spilt molybdenum sleeve with "Mobraze" as seen in the center of Fig. 4. The sleeve is then Heliarc welded into the finished cathode structure as shown on the right.

Theory

Several theories have been proposed to explain the high emission and low evaporation rate of this cathode. The one held by the authors to be closest to the true picture is described here. Several experiments are being performed at the present time to clarify the picture.

As the temperature is increased the thorium hydride loses its hydrogen and starts to alloy with the tungsten[2]. At the same time thorium carbide is being formed from the carbon available in the tungsten carbide. If the sintering temperature is not high enough the carbide formation is the principal reaction. This material is unstable in the presence of wet air and will form acetylene and ThO_2 according to the reaction:

$$ThC + H_2O \rightleftarrows ThO_2 + C_2H_2 + \text{other hydrocarbons.}$$

In the tube, then, the excess tungsten carbide will react with the thorium oxide and form CO giving a gassy tube.

$$ThO_2 + 2W_2C \rightleftarrows 4W + Th + 2CO$$

Heating high enough and long enough while pumping the tube, however, will minimize this problem.

At higher sintering temperatures the tungsten and thorium are alloyed sufficiently to stabilize the carbide. Also aiding stabilization, the higher density prevents moist air from coming in contact with the majority of the carbide. An alternative explanation of the stabilization of thorium carbide has been given by Das[3].

During tube operation the optimum coverage of thorium on the cathode surface is supplied by thermal breakdown of the thorium carbide and diffusion to the surface. This source of thorium is believed to hold the evaporation rate to a smaller value than if thorium diffusion were the only rate-limiting reaction. A layer of oxygen may or may not be present between the thorium on the surface and the tungsten since the cathode is not heated over 1650° after air exposure. The high secondary emission could be explained by the presence of such a layer[4]. Little difference in performance is found with variation of thorium content between ¼% and 1%. Variation of W_2C between 1% and 20% has quite an effect on density of the cermet but seems to have no noticeable effect on cathode performance.

References

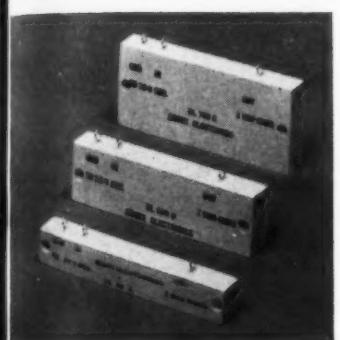
(1) Lea-Wilson, C. P.: J. of Electronics *1*, 529, (1956).
(2) Cooper, H.S.: U.S. Patent No. 1,732,326, (1929).
(3) Das, D. K.: Seventeenth Annual Conference on Physical Electronics, (1957), p. 1.
(4) Coomes, E. A.: Phys. Rev.: *55*, 519 (1939).

Delay Line Survey

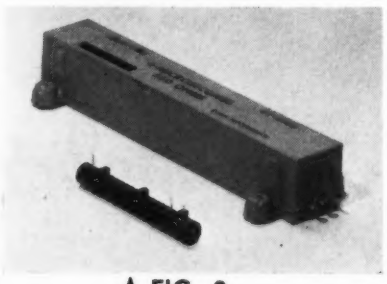
(Continued from September-October Issue)

DELAY LINE data from three additional manufacturers, which arrived too late from inclusion in the September-October issue of MILITARY SYSTEMS DESIGN, are provided in the table below. These do not represent all types of delay lines stocked by these manufacturers, nor are their many unique characteristics completely reported in this brief tabulation. Complete characteristics and data may be secured by request direct to the manufacturer.

Feature articles on Delay Lines and their applications which could not be accommodated due to lack of space in our September-October issue have enabled us to continue the emphasis on Delay Lines in Military Applications into this issue. They will be found on pages 306, 308 and 322.



◄ FIG. 1.



▲ FIG. 2.

Manufacturer	Type	Principle	Time Delay (usec)	Rise Time (usec or % delay)	Attenuation (db or % delay)	Impedance (ohms)	Features
Essex Electronics, Div. of Nytronics, Inc. 550 Springfield Ave. Berkeley Heights, N. J.	Stock Standard Modular DLO5A-DL700C (Fig. 1)	Distributed Constant	0.05-7.0	15%	$(T_d)^{1/2}$ db max	1000	Encapsulated units, stacked for longer delays.
	H-792	Lumped Constant	0.70 tapped every .07 μsec	0.08 μsec	1 db max	200	Epoxy encapsulated, Highly stable.
	J-194 (Fig. 2-bottom)	Distributed Constant	0.20	0.05 μsec	1 db max	1600	Molded epoxy for printed circuits; low cost; flame resistant.
	C-706 (Fig. 2-top)	Lumped Constant	6.0	0.7 μsec	2 db max	560	Hermetic seal MIL-F-18327; —54° to 80° C, meets MIL-STD-202, Methods 101, 102, 106 and 201.
	H-966	Network Synthesis	20.0	0.75 μsec	6 db	1000	As above plus MIL-E-5400
Laboratory for Electronics, Inc., Computer Products Div., 1079 Commonwealth Ave. Boston 15, Mass.	11445 (Fig. 3)	Fused Quartz Delay Line	500	0.1 μsec max (10 mc min. bandwidth)	58 max at 30 mc	100	Weight either 1¼ or 2½ lbs, low spurious
	43191	Fused Quartz Delay Line	2.5	0.1 μsec max (12 mc min. bandwidth)	47 db max at 60 mc	100	30 db min less than 1 oz.
	35437	Fused Quartz Delay Line	8.0	0.12 μsec max (6 mc min. bandwidth)	60 db max at 30 mc	100	3rd time: 40 db min.
	11520 and 11510 (Fig. 4)	Fused Quartz Range Marker	6.1	0.10 μsec (7 mc bandwidth)	46 db at 30 mc Decay rate 1-1½db/pulse	100	Less than 1 oz/1000 yds per pulse.
Valor Instruments, Inc. 13214 Crenshaw Blvd. Gardena, Calif.	C Series (Fig. 5)	Lumped Constant Fixed	0.05-6.0	0.01-0.5	1—5%	100—3,000	Smallest lumped constant lines available, high stability.
	M Series	Lumped Constant Fixed and tapped	0.1-12.0	0.01-1.0	1—10%	100—2,000	Molded for printed circuit or special applications
	N Series	Lumped Constant Fixed	0.2-1000	0.01-20.0	0.1—6 db	100—2,500	Provides highest delay/rise ratio and longest delays. Temperature compensated.
	443 Series	Variable Lumped Constant	0.0125-12.6	0.05-0.3	3.5—30%	100—500	Binary type switching
	S32 Series	Variable Lumped Constant	0.5-10	7%	5%	200—600	32 taps with rotary switch

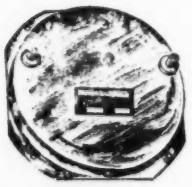


FIG. 3.

FIG. 4.

Note: Laboratory For Electronics, Inc., was listed in error in the September-October issue of MILITARY SYSTEMS DESIGN among firms producing delay lines solely on a custom basis. Although much of their production is for specific customer requirements, the foregoing are representative of delay lines stocked for "off the shelf" delivery by this company.

FIG. 5.

Instrumentation for Space Medicine Applications

WILSON GREATBATCH, Taber Instrument Corp.

RECORDING the physiological reaction of the human pilots in Space Project Mercury will require physiological instrumentation with characteristics superior to the best clinical instruments, but also meeting the most strigent reliability and ruggedness requirements.

The same methods used to obtain superior reliability in regular missile electronics can produce reliability in airborne medical electronic equipment. At least seven factors can be maximized to ensure a superior reliability level in missile electronics:

1. *Design Factors,* Certain factors in circuit design have proven very helpful in eliminating or minimizing many of the failures which can occur in missile circuitry. These factors, which are discussed below in detail, include such measures as limiting the maximum possible current which can flow during overload, reducing the total number of parts in a circuit through simplification and rewriting clinical specifications in certain instances where the change will produce a higher order of reliability.

2. *Transistor Selection.* It has long been known that transistor quality is in some measure linked to transistor performance at high temperatures. Thus, germanium transistors which can operate at 100°C are generally of superior quality to those which must be limited to 75°C. This means that for better reliability it is usually preferable to restrict transistor selection to 100°C types if germanium is used.

Although a year or two ago the overall quality of silicon transistors appeared to be considerably better than the best germanium types available, at the present time there appears to be little choice between germanium and silicon types if the environmental temperature will not exceed 60° or 75°C. For higher temperatures there is little question that silicon should be chosen. Also at that time germanium transistors were, in general, quieter than silicon types, but in general noise is now no longer a factor in the choice between germanium and silicon. In the circuitry described below, the only advantage of silicon is in its superior performance at higher environmental temperatures and its superior safety factor, should an environmental temperature rise temporarily—as might accidentally happen in a missile capsule standing in the desert sun.

The only advantage of germanium is cost. One naturally feels that cost should not be a factor in the choice of missile electronics. Surprisingly enough, many of the missile procurement agencies are exceedingly cost conscious and are quite willing to specify that environmental temperatures will be held within limits compatible with the use of germanium transistors, rather than specifying the more costly silicon units.

3. *Transistor Aging,* The transistor, as it comes from the factory, is not considered a particularly reliable component although far superior to a comparable vacuum tube. Each transistor is subjected first to tests for Ico and for beta. It is then aged 500 hours in an oven at the maximum temperature for which it is guaranteed. No power is applied during this test. Five times during this period the transistor is removed from the oven and placed in a container of dry ice for 30 minutes. At the completion of the test the transistor is again checked for Ico and beta. Any transistor which has changed in Ico by more than one microampere, changed in beta by more than 30%, or has dropped to a beta of 30 or less is then discarded. We lose about 0.5% of our transistors in this aging cycle.

Bulk impurities and surface impurities are disclosed by the heat test. Temperature cycling shows up leaks in seals, since moist air will be pumped in and out of the transistor, resulting in significant changes in characteristics. From this point on, our failure rate on transistors is lower than that of other circuit components, as resistors and capacitors.

4. *Resistor Selection.* Believing that the composition carbon resistor did not give highest reliability, for several years we used only the best wire wound resistors in our circuitry, regardless of whether the application called for a precision resistor or not. We soon found that wire wound resistors, while their failure rate was very low, still gave us more failures than any other component. When metal film resistors became available, we immediately subjected them to exhaustive tests and very shortly replaced the wire wound resistors in our designs with metal film types, except for applications where two resistors must be accurately matched. Our acceptance test on resistors involves five temperature cycles from +175°C to −60°C followed by a 300% power overload for 3 sec. We have yet to find a bad resistor on incoming inspection after having gone through several thousand units. Our subsequent failure rate on metal film resistors is so low as to be statistically insignificant.

5. *Capacitor Selection.* Because the life of a paper capacitor is dependent on the DC voltage placed across it, paper capacitors are operated at only a fraction of their normal permissible operating voltage. For capacitors in the lower ranges, mica and glass types give no trouble whatsoever. Where capacity variation with temperature is not a problem, the new high-capacity ceramic types show excellent reliability.

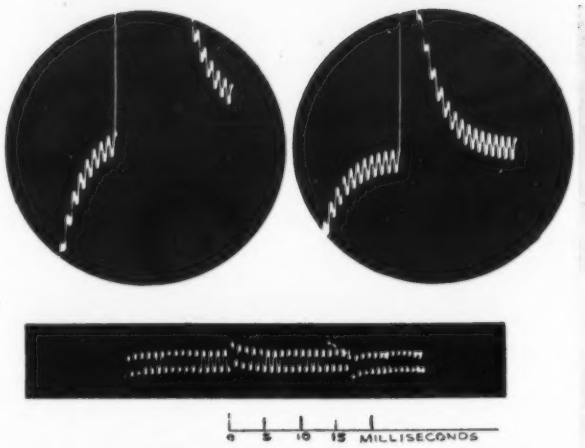


FIG. 1. TRANSIENTS impressed on 1 kc, 100 uv rms sinewave signal show signal revovery within 10 msec when dc amplifier design is used. First circle shows 60 mv overload transient; second circle 6 mv overload; strip shows application of 50 μv square wave of about 15 msec duration.

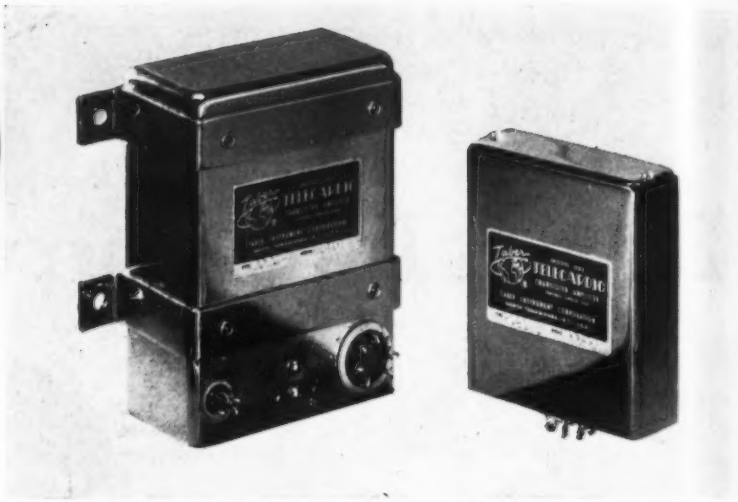


FIG. 2. ELECTROCARDIOGRAPH amplifiers utilizing high reliability design factors are designed for physiological monitoring of men in space. Model 202-G-4 (left) has 0.2 cps-3kc bandwidth, 60 db gain. Model 202-G3 (right) is subminiaturized with 2 cps-10kc bandwidth, 54 db gain.

The advent of the solid tantalum capacitor has solved a problem in the higher microfarad range. Here again a large safety factor is desirable and we like to run solid tantalum capacitors at about ¼ of their rated DC voltage. We have seen some of the newer tantalum capacitors which are being developed in the form of micromodules of the Signal Corps type. It is quite apparent that the size of the solid tantalum capacitor is decreasing every month and the time is very close when the capacitor will no longer be the largest component in a circuit.

6. *Quality Control in Assembly and Testing.* The reliability of a circuit always has been, and always will be, a direct measure of the meticulous care which the technician puts into wiring and testing. The time has not yet come when the machine can surpass the expert technician in this function and thus, the physchology, the incentive, and the moral integrity of the technician who wires and tests the unit is of paramount importance in producing a reliable instrument.

In our plant, no more than one or two men ever touch an amplifier from the time the parts are selected until the final testing is done. These men are in close contact with the designer of the instrument and thoroughly understand the function of the circuit, the purpose of each part and the importance of putting their best work into it. Each man knows the final customer for that particular instrument and the application into which it will be put. Needless to say they take great pride in their work.

7. *Application Engineering.* It is important for our sales engineers to follow the installation of the instrument and to actually see the test runs in the final application. If application difficulties arise, it is essential that the sales engineer be so qualified that he cannot only identify the reasons for trouble, but be able to determine any necessary design changes in the instrument which will improve performance or improve reliability. This means that the factory man who shoots trouble at the customer's site should preferably be the designer himself or someone who was closely connected with the design work. This is a novel approach and requires some excellent planning by management.

Reliability, Design Factors

It is possible to enhance reliability through the inclusion of certain design factors. One bad property of transistors, not found in vacuum tubes, is that a reversal of collector voltage polarity will permit excessive currents to flow, resulting in possible damage to the transistor. The inclusion of limiters in the design to prevent such currents from reaching damaging levels represents a distinct contribution to reliability.

Other design factors can similarly make the instrumentation system less dependent on environment. Most of transistor dependence on temperature can be removed if the operating point of each individual transistor is prevented from changing with changes in temperature. For instance, the use of nearly 100% DC feedback around multiple stages of amplification can lock down transistor operating points over wide ranges of temperature variations. Also, the elimination of coupling capacitors results in an improvement in reliability through simplification and also makes best use of the DC response of the amplifier. Thus for highest circuit reliability, it is almost axiomatic that all amplifier stages be DC amplifier stages with large amounts of DC feedback around multiple stages.

One trouble often encountered in physiological recording is the application of a strong step function of signal to the instrument as the result of a jerk or twitch on the part of the subject. When this happens, amplifier stages along the chain tend to saturate and, in the case of capacitor-coupled amplifiers, each amplifier comes out of saturation in turn, resulting in a whipping back and forth of the penwriter needle for as much as several seconds before recording is resumed. The use of DC coupled stages minimizes overload transients to a single over-shoot which quickly returns to the base line. Fig. 1 shows one example of a square wave transient impressed on a one-kilocycle sine wave. In space environment testing if one must wait three to four seconds before recording can be resumed after each of such transients, most of the record might be unreadable. If however, we lose only ten milliseconds, during each such transient, very little recording time will be lost. Here again a design feature applied on the drawing board can vastly improve reliability of the equipment in the missile.

The human subject in the missile environment is subjected to much more than is normally encountered in the laboratory. The conventional clinical electrocardiograph has a low frequency cutoff in the neighborhood of 0.2 cps. This means that much of the muscular motion of the patient will fall within the electrical band pass of the amplifier and thus, muscle potential will cause significant amounts of base-line weave. Many physiologists feel that there is very little information for space travel in the lower part of the frequency spectrum. Thus a low frequency cutoff around 2 cps or even 10 cps may greatly reduce base line weave. We hope that discussions at space medicine symposiums during the coming year will result in a firm set of new specifications.

The packaging of electronic equipment for space medical applications is important. The space and weight requirements of modern clinical equipment are naturally prohibitive in the missile situation; however reliability cannot be sacrificed. The first step downward in volume and weight comes with transistorization but utilizing only components which comply with military specifications, packaged for maximum sturdiness. If the unit is potted solidly in a moisture-resistant potting compound with external protection, hermetic sealing will generally not be required. An EKG package of this type will weigh less than 1 lb, will operate satisfactorily in vibrations of 40 G at 60 cps over temperatures of −50°C to +50°C, and will have the seven factors mentioned above built-in to maximize reliability (Fig. 2).

The next step in miniaturization would include the use of non-military specification components such as hearing-aid type transistors. This results in some loss in reliability since the manufacturers of such transistors will not, as a rule, guarantee them to military specifications. For example, we know of no hearing aid type transistors which are guaranteed to 100°C. However, missile people are sometimes willing to sacrifice a little reliability for a radical decrease in weight and space.

Another step down in size and weight can be accomplished by going to uncased printed circuit boards which are not potted but merely dipped in a protective plastic coating. Usually such boards are plugged into sockets rather than permanently wired in. Many reliability engineers feel that this technique is not recommended in flight components at the present time.

Micromodule electrocardiographs requiring less than 1 cubic inch volume can now be built using micromodules such as those developed under the Signal Corps program. One can now purchase a 4μfd, 6 volt capacitor, five metal film resistors on a single board, and series combinations of ceramic capacitors and metal film resistors; each board being 0.3″ square and less than 0.30″ thick. Transistors of the hearing aid type are sufficiently small to be mounted on micromodule blanks; however, within the next year or two, reliable military transistors will also be available in micromodule wafer form. Thus it is quite feasible to build complete electrocardiographs, electroencephalographs and electromyographs together with a short-range radio telemetering device into a pilot's crash helmet, to free him from entangling wire connections while in the space ship, or to permit telemetering to continue, should he need to "bail out".

In an ultimate step, now seen as about ten years distant, whole circuits may be built on semiconductor plates. Such "molecular circuits" may require active elements similar to the tunnel diode to avoid the problem of inter-contamination between semiconductor elements within the same hermetic enclosure.

New types of low-energy power supplies, perhaps using nuclear energy, may even allow the implanation of instrumentation capsules within the body of a space pilot.

One cannot but wonder what the future holds for this new field of instrumentation. Already we can accumulate more data in a space capsule than we can conveniently record or telemeter to ground. What we most need now are improvements in the physiological transducers which produce some of our signals, and a more concise statement from space physiologists on what really needs to be measured and controlled in space flight.

FIG. 1. ACCURACY AND LEGIBILITY are salient features of new barometric altimeter, developed by the Bulova Watch Company. Servo motor drives 40-ft tape past window to give direct-reading indication of altitude during either power dive or climb without "hunting" or fluctuation. Knob sets in barometric correction for sea level.

FRICTIONLESS DIFFERENTIAL TRANSFORMERS ASSURE MAXIMUM ACCURACY FOR NEW ALTIMETER

THE new servo-driven Bulova altimeter (Fig. 1) ordered for test and evaluation by the Air Force and reported ten times more accurate than conventional altimeters, employs a design principle which departs from standard practice. Using two Atcotran differential transformers, the barometric sensing elements in the Bulova altimeter are freed from all mechanical work, which results in unprecedented accuracy and readability.

The Atcotran differential transformer, (Fig. 2) an exclusive development of Automatic Timing & Controls, Inc., King of Prussia, Pa., is an electromechanical transducer for converting displacement into an ac voltage. Among the advantages of using the differential transformer rather than other available devices are: (1) Its ability to convert the mechanical motion to a voltage *without extracting work from the mechanical system;* and (2) its ability to provide an electrical signal which can be algebraically summated with one or more other signals from similar differential transformers.

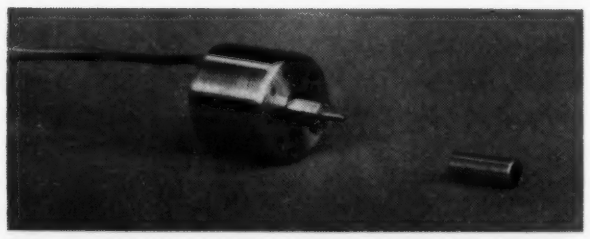


FIG. 2. DIFFERENTIAL TRANSFORMER removes mechanical loading and friction from aneroid capsule sensors, also provides dynamic correction for acceleration effects so that altimeter is not affected during High-G maneuvers.

Accuracy of the new Bulova altimeter is said to be unparalleled, having an error of less than 10 feet at sea level. Sensitivity is such that raising or lowering the Bulova altimeter as little as two feet will give a visible indication on the scale at sea level. Altitude is read in Arabic numerals from a 40-foot logarithmic tape, instead of conventional pointers and dials. The scale of the tape allows one-fifth of an inch between graduations, which, at sea level, corresponds to an altitude difference of 10 ft.

Altimeter Sensor is Frictionless

The effectiveness of the novel design in eliminating friction and load-reaction from the sensing system can best be appreciated from a study of the system schematic, Fig. 3.

The altimeter's sensing elements are Melchior-type aneroid capsules, arranged in a series of three (1). The free end of this group of capsules is directly connected to an Atcotran differential transformer armature (2). The outside air pressure to be measured is communicated to the capsule chamber by way of a pressure connection (5) and tube connected to the outside static pressure tube. Increasing altitude causes all the capsules to expand, thus displacing the armature of the differential transformer to the right from null. Decreasing altitude, causing contraction of the sensing elements, moves the armature in the opposite direction, left of null.

Each of the two Atcotran coils (3) carries a primary and a secondary winding. The primaries are connected in series to a 115 volt, 400 cycle AC supply (not shown), and the secondary output voltage depends on the measured pressure which controls armature position. With this system, the output of these coils can only be kept in balance by the armature occupying a null position between them; hence, any change from the null position because of altitude or pressure changes will cause a signal in one direction or the other. Null voltage of the transducer as applied in the altimeter circuit is less than 2.5 millivolts. Output voltage of the transducer is 1.5 volts if displacement over the full linear range of ±.020 inches is employed.

In an aircraft altimeter, the source of mechanical displacement is the pressure sensing element. In all

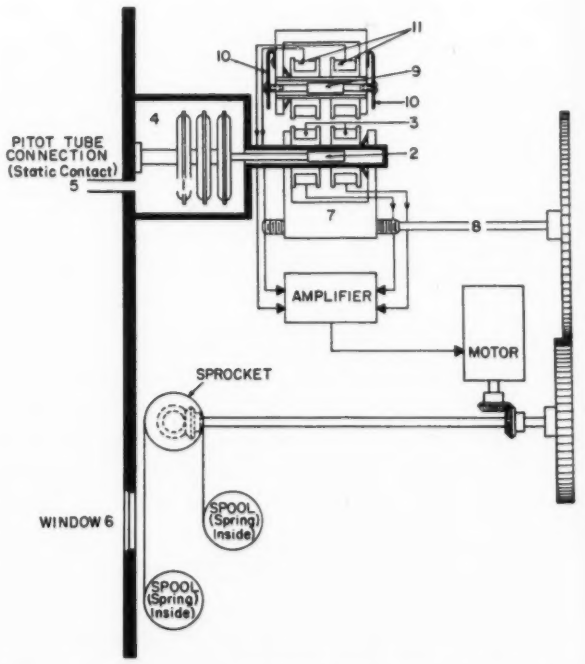


FIG. 3. ALTIMETER BLOCK DIAGRAM. Numbers point to features discussed in text. 115 v 400 cps power supply to Atcotran differential transformers is not shown.

mechanical altimeters, this element is required to do work—to compress the pointer linkage preload spring and overcome the friction present in the pointer linkage bearings. The result is a lack of sensitivity to small changes in pressure, a slow response to rapid changes in pressure, and a lack of repeatability due to mechanical hysteresis and/or friction. Since the differential transformer exerts no force on the armature at null and only several hundredths of a gram at maximum displacement, it seldom extracts an amount of work sufficient to affect the performance of most sensing devices.

Using the fact that a differential transformer exerts no force at null, Bulova Research & Development Laboratories designed the altimeter so that the differential transformer exerts no force on the pressure sensing element. A change in altitude (pressure) causes the element to displace the armature of the differential transformer which, in turn, transmits an electrical signal to the electronic amplifier. The output of this amplifier drives a servo motor which re-positions (7) the coil of the differential transformer until the armature is once again centered (at null) within it—the force of the armature again being zero. This same servo motor also drives the 40-foot indicating tape (6).

In an altimeter designed for high-performance aircraft, the effect of acceleration on the accuracy of an altimeter cannot be overlooked. Bulova's engineers used the principle of algebraic summation of the electrical signals from two differential transformers to compensate for acceleration stresses on the pressure sensing element which would cause erroneous altitude readings. The second differential transformer and armature (9) has no mechanical connection to either the pressure sensing element or to the servo motor. The armature (10) is spring loaded within the differential transformer, so that when the altimeter is experiencing no acceleration, the armature is at null (no resultant output). When the altimeter experiences an acceleration, the armature moves relative to the transformer and an electrical output signal (11) results. The outputs of the two differential transformers are algebraically summated (in this case, subtracted) so that an electrical signal equivalent to that signal component caused by the acceleration of the pressure sensor is subtracted from the input to the amplifier. The servo motor thus moves only in response to pressure—not acceleration.

Algebraic summation requires that the output of the differential transformer be linear with displacement, that the phase angle and sensitivity of both differential transformers are the same, that the wave forms are similar and that phase shift be practically zero over the range. These requirements are met by using two Atcotran differential transformers to form the vital bridge between the sensing elements and the servo system of the Bulova altimeter, thus providing unprecedented accuracy, precision and readability.

FOR MORE INFORMATION CIRCLE 78 ON READER-SERVICE CARD

FIG. 1. TRANSISTORIZED GENERAL PURPOSE RPC-4000 Electronic Computing Basic System consists of computer console at far right, combination punched-tape reader and punch and Royal Electric Typewriter with desk and chair. No site preparation or installation costs are needed despite the system's high capacity of 240,000 operations per minute.

COMPACT MODE

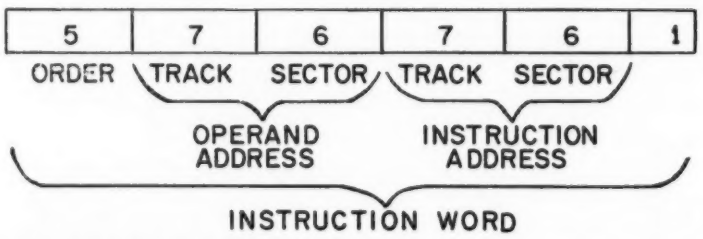


FIG. 2. INSTRUCTION WORD consists of Operand address, giving location of the operand; and the Instruction address, giving the location the next instruction to execute. A **zero** in the index reference position means the index register has no effect on the instruction. If a **one** appears, the actual address of the instruction will be the sum of the operand address and the contents of the index register.

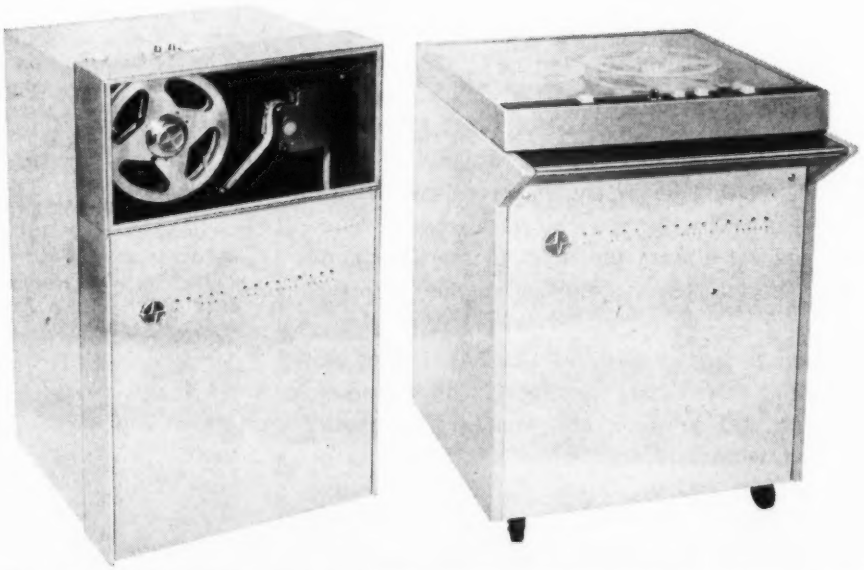


FIG. 3. HIGH-SPEED PUNCH (300 characters/sec) and Reversible Photo Electric Tape Reader (500 characters/sec on right) are available as optional accessories to speed the solution of scientific computations or standard business-type operations of the RPC-4000 Computer.

DEHigh-Capacity Electronic Computer

BIG BROTHER to the versatile LPG-30, the new RPC-4000 Electronic Computing System (Fig. 1) is a fully transistorized, general purpose electronic digital computing system suitable for engineering problem solutions and for standard business-type operations such as inventory, payroll, sales analysis, and other management control functions.

The RPC-4000 Computer, a product of the Royal Precision Corporation (owned jointly by Royal McBee and General Precision Equipment Corp.), will be offered both for sale and for lease by the Data Processing Div. of Royal McBee Corp., Port Chester, N. Y. No site preparation or installation costs are said to be necessary.

Capable of operating on 9-digit numbers at rates up to 240,000 operations/min., the high computing speed of the RPC-4000 is said to be due to a breakthrough in design concept rather than to a proliferation of hardware. New features include a versatile list of 42 commands; an index register that allows high-speed instruction modification; repeat execution feature; high-speed input-output equipment and an 8-word accumulator for block operation (8 sums can be accumulated simultaneously).

One of four registers provided, the command register uses the "one-over-one" address system. The first address contains the location of the operand. The second address gives the location of the next instruction to execute. This arrangement permits the programmer to optimize his system without being restricted to a sequential machine-specified instruction order. The least significant bit of the instruction word (Fig. 2) contains a reference to the index register (a zero means the index register has no effect on the instruction). If a one is present, the actual address of the instruction will be the sum of the operand address of the instruction and the contents of the index register. Thus a programmer may modify an address by merely modifying the contents of the index register. A variety of programs can be stored permanently for instant access when needed.

Air-borne Memory Drum

The computer's main memory is non-volatile, retaining all stored information even when power to the equipment is interrupted. The entire magnetic-drum memory section is enclosed in a dust-proof case. The drum is tapered and floats on a cushion of air which automatically holds the drum in operating position against the miniaturized magnetic heads when the power is turned on. When the machine is idle, the drum rests safely away from the miniaturized heads.

The memory has a storage capacity of 8,008 words, each with a length of 32 usable bits (to accommodate a 9-decimal digit number), allowing great problem-solving flexibility. Access time to the main storage averages 8.5 milliseconds. A special masking feature permits a search of the memory for full or partial words at a sustained rate of 180,000 words per minute. 3000 memory words can be scanned in less than 1 second for full or partial equality (or superiority) to a key word. Increments of 1024 words may be "locked-in" by switches so that they cannot be altered by program or operator error. A high-speed dual-access line gives extra-rapid access to a part of the memory (136 words) in 1 to 6 milliseconds.

The arithmetic and control section of the memory includes three 1-word registers and one "one-or-eight" word register which provides for block arithmetic and block transfers without special commands.

Peripheral Equipment

The tape typewriter system consisting of the input-output Royal Electric Typewriter with its specially-designed desk and chair, plus a console housing a combination punched-tape reader and punch, is standard equipment as shown in Fig. 1. These units may be interconnected in any combination for on-line or off-line operations. Typewriter speed is 12 characters/sec, while tape reading can be accomplished at 60 characters/sec and punching at 30 characters/sec on 7-channel tape. A reversible photoelectric tape reader with a capacity of 500 characters/sec and a high-speed punch (Fig. 3) with a speed of 300 characters/sec are available as optional accessories for system expansion. Standard equipment provides compatibility with existing paper tape systems. A Universal Translator, to be available later, will further extend compatibility.

Peripheral equipment available in 1961 will include a magnetic tape drum with a maximum capacity of about 200,000 computer words per replaceable tape cartridge. Lower capacity tapes having faster access times may also be used.

The mobile RPC-4000 Computing System draws less than 10 amperes from a standard 110v 60 cps line, and the weight of the basic system is well under 1000 lbs.

FOR MORE INFORMATION CIRCLE 79 ON READER-SERVICE CARD

FIG. 1. PRINTED CIRCUIT BOARD to be tested is connected and the corresponding patch board put in position. Operation of the Analyzer is automatic after a simple starting procedure.

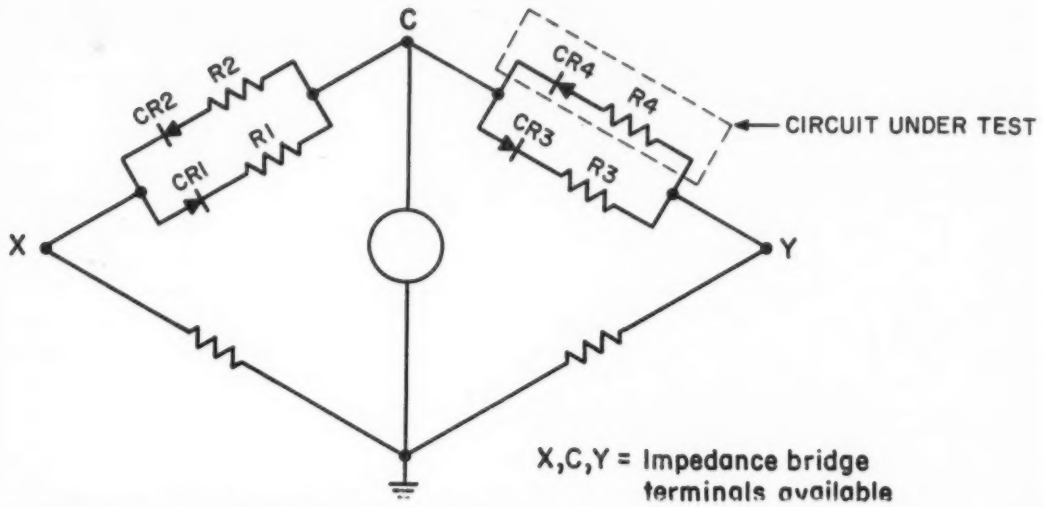


FIG. 2. BRIDGE CIRCUIT SHOWN is used when testing diodes with T.E.C.'s System Analyzer at Lockheed's Missiles and Space Division, Sunnyvale, Calif. The resistors R1 R2 and R3 are used to limit current flow and to prevent possible diode failure. R4 is part of the circuit under test or is added.

SYSTEM ANALYZER CHECKS DIODE CIRCUIT IMPEDANCES

PRINTED CIRCUIT boards, consisting of resistors, capacitors, transistors, diodes and relays are being automatically tested at Lockheed's Missiles and Space Division, Sunnyvale, Calif. Mr. L. C. Sundstrand, Lockheed Engineer, reports, "A new system Analyzer developed by Technical Electronics Company, Culver City, Calif., is providing faster, more reliable automatic testing of our printed circuit assemblies." An impedance comparison test is used in most cases, (Fig. 1) comparing against a master circuit, a master component, or a standard.

"We believe that this is the first time diodes have been checked on an automatic tester using ac with an impedance bridge," Mr. Sundstrand added. The same principles described here (Fig. 2) for diode tests are applicable to transistors by using the base-collector or base-emitter terminals as diodes. Lockheed uses patchboards to "set-up" the test for the printed circuit boards being checked. The sequence of circuit tests are listed on paper keyed to test-point symbols; these 'print-out' when a fault is pin-pointed (Fig. 3).

The analyzer system specified by Lockheed can be "added-to" as requirements demand because of the modular construction of the T.E.C. System Analyzer. Lockheed's system now includes a scanning system, a patchboard, hi-pot unit, voltage percentage tester and an impedance comparator (Fig. 4).

The scanning system consists of a system analyzer control unit, stepping switches, program selector, and a junction box. The function of the scanning system is to select the circuits for sequential testing. Each step switch will accommodate up to 100 circuits (Lockheed uses two switches). The control unit and the junction box may be used with up to 52 step switches. The step switches are the fundamental units of the scanning system; they sequentially connect the circuits to be tested and the reference circuits, if any, to the test equipment. The control unit selects the active step switches for a particular test; a test may use all or any number of the step switches. In addition, it selects the switch step-rate. Up to 10 circuits may be tested per second.

The control unit visually indicates the identity of the circuit under test at a given instant. When a faulty circuit is encountered, the test halts until manually stepped past the faulty circuit. Stepping is then automatic until the next faulty circuit is encountered. A Clary type printer prints out the identity of each faulty circuit.

Lockheed specified a T.E.C. impedance comparator

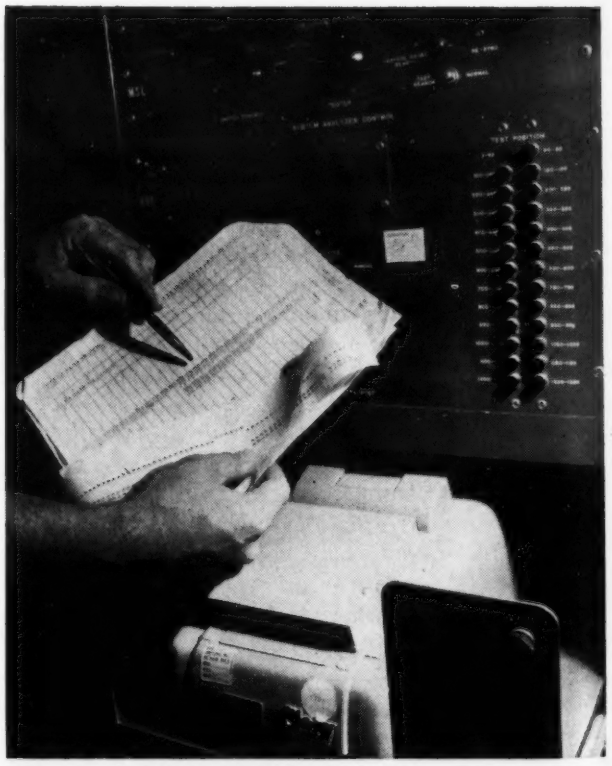


FIG. 3. A DISCOVERED FAULT causes the Clary printer to print out a fault location indication which is compared with the Master Circuit Sequence List to determine location of the fault.

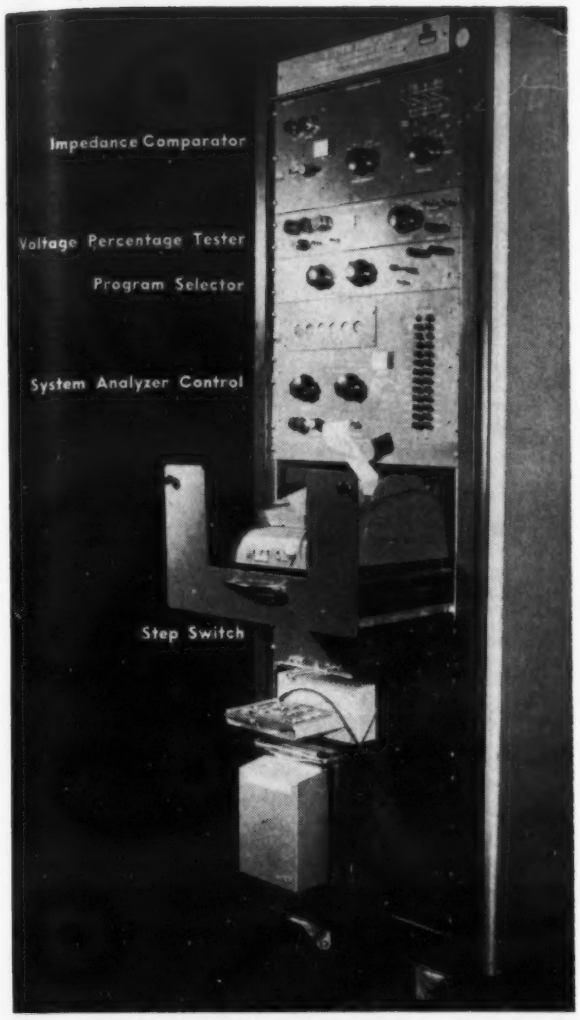


FIG. 4. T.E.C. SYSTEM ANALYZER used at Lockheed includes an Impedance Comparator, Voltage Percentage Tester, Program Selector, System Analyzer Control and two Step Switches. The Clary printer is mounted on a draw-out shelf. A plug-in arrangement is provided for the printed circuit board; a standard patchboard is mounted at the bottom of the cabinet.

module to test continuity and any combination of R, L, and C. The tolerance allowed and bridge frequency required for each test is selected before starting the test.

The program selector is of considerable convenience when one or more tests are combined, using the step switches, control unit, and junction box. In addition, it doubles the indicating capacity of the control unit.

The voltage percentage tester is for pre-selected tolerance testing of dc regardless of polarity, or of ac at frequencies from 0 to 15 kc. Indication is LOW, GO and HIGH.

"The T.E.C. System Analyzer, as adapted to our requirements at Lockheed, provides the stringent standards for reliability typical of our space and missiles programs. We are testing solid-state printed circuit boards at least ten times faster than was previously possible," states Mr. Sundstrand.

Delay Equalization in Voice Bandwidth Circuits

A rectangular pulse, or any other complex wave, is composed of energy at a series of related frequencies whose amplitudes and phases are uniquely related in time. The impulse waveform is the result of the continuous vectorial addition of these components with time. Any shift of the relative time position of any component will modify or distort the waveform.

Any network, such as a wire line complex comprising a telephone system, in which energy at an upper frequency travels more slowly than energy at a lower frequency, could cause this effect. This difference in transmission time with frequency is called *differential delay* and the effect is called *delay distortion.*

The human ear apparently is quite insensitive to this form of distortion as long as all of the required spectrum components are received with reasonably correct amplitude relationships. So our telephone networks have been designed to transmit the required voice spectrum with minimum amplitude distortion but with little or no regard for delay distortion. However, data signals, which require faithful envelope reproduction, are seriously affected by this distortion.

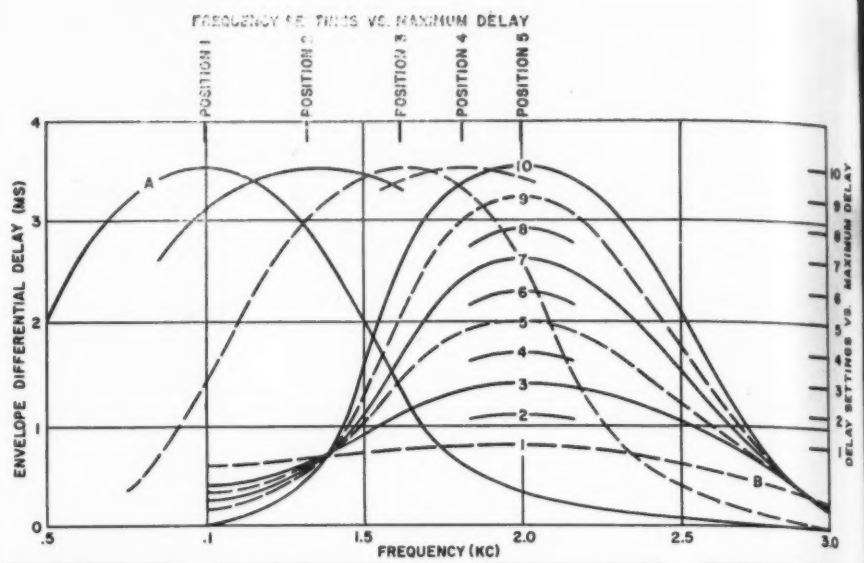


FIG. 1. DELAY EQUALIZATION RANGE. Two independent adjustments cover the range; five positions of one knob select the frequency of maximum delay (horizontal scale) while ten positions of other knob adjusts the peak delay at this frequency. Curves A and B represent extremes of available adjustment.

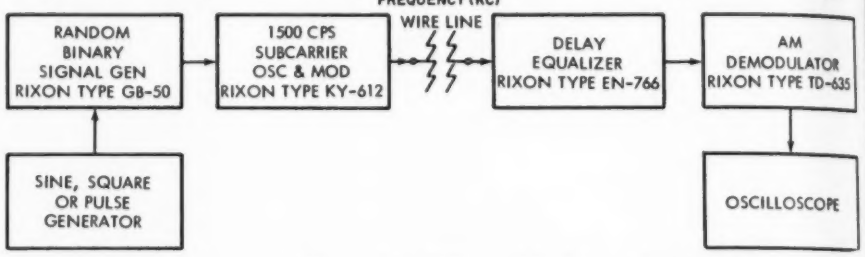


FIG. 2. TEST SETUP for Delay Equalization of a Wire Line, using a transmitted Random Binary Signal and Wide Range Delay Equalizer.

Delay Equalization

Fortunately, since all of the information is presented to the receiving end, something can be done to correct the situation. The original waveform can be restored by eliminating the differential delay. This is done in practice by an additional device which slows down fast-traveling frequencies more than the slow ones. Thus any transmission network distortion may be "built-out" or delay-equalized by an appropriate device whose delay characteristics complement the line characteristics.

Since the differential delay characteristics of real networks vary widely, it is not practical to devise a single fixed-delay compensator for all networks. The Rixon Type EN-766 Delay Equalizer has been developed to provide fast manual selection of any one of 50 different complementary delay characteristics. The range of these characteristics is shown in Fig. 1.

Since the compensating delay network introduces considerable loss, a practical equalizer must include amplification. The type EN-766 Delay Equalizer employs four tandem delay networks with transistor amplifiers between stages. The gain has been adjusted to exactly compensate for the loss so that a zero dbm input produces a zero dbm output. Input and output circuits are 600 ohms balanced to ground.

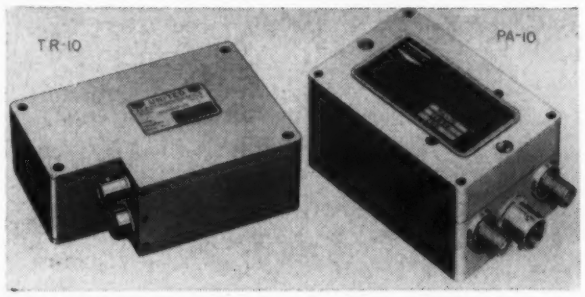
Physical adjustment of delay equalization can be accomplished with signals on the line. This is a powerful dynamic means for accomplishing a practical compensation in a short time. The delay equalizer is inserted in the line ahead of the receiving terminal equipment and an oscilloscope or other suitable indicator is connected to the receiving equipment at an appropriate place to show the recovered signal envelope (Fig. 2.) The two adjustments are then systematically varied until the recovered signal envelope most closely resembles the known envelope of the transmitted signal.

If equalization must be accomplished prior to the transmission of operational traffic, the Rixon Type GB-50 Random Binary Signal Generator can be employed at the transmitting terminal to produce a pattern in which envelope delay distortion shows as a time error in the axis crossings. Compensation which minimizes this error is very effective. (*From* 4-*page Rixon Engineering Bulletin No.* 64.—*Rixon Electronics Inc.,* 2414 *Reedie Drive, Silver Spring, Md.*)

FOR THIS LITERATURE CIRCLE 81 ON READER-SERVICE CARD

FM Telemetering Transmitter-Power Amplifier System

A true FM 2.5 watt telemetering transmitter (TR-10), in which the output frequency is modulated by the intelligence transmitted, accepts inputs from all subcarrier oscillators operating in channels which meet MIL-STD-442. All low-level and frequency-determining stages are transistorized, with ruggedized miniature tubes used in the output stages; weight 17 oz.



FM TELEMETERING Transmitter, TR-10 may be used alone or followed by Power Amplifier PA-10 to provide total output of 10 watts for missile and other light-weight applications.

For applications where additional signal strength is required, a companion 10-watt power amplifier (PA-10) using a push-pull grounded grid configuration withstands operating temperatures to 200°F, vibrating of 20G, and shock of 120 G. Weighing only 9 oz, it is encapsulated to operate at all altitudes and to exceed Mil-Specs for salt spray and dust.

Both units, flight-proven in numerous missile programs, are developments of United Electro Dynamics, 200 Allendale Road, Pasadena, Calif. Complete technical specifications are available on request to the manufacturer.

FOR MORE INFORMATION CIRCLE 82 ON READER-SERVICE CARD

Low-Loss Microwave Ferrites

A new line of Alumina-substituted Nickel Ferrites, developed for microwave devices designed to operate in the low-loss region above resonance, are available in standard bars or special shapes to meet customer's requirements by Kearfott Co., Inc., 500 Main Ave., Clifton, N. J.

Typical characteristics are shown in the table below:

Type Designation	AN-20-MW	AN-25-MW	AN-30-MW	AN-35-MW
Saturation Magnetization B_s (Gauss)	1300	750	650	300
Remanent Magnetization B_r (Gauss)	700	350	325	115
Coercive Force (Oersteds)	6	16	12	25
Curie Temperature T_c (°C)	450	450	400	400
Line Width Δ H (Measured at 9 Kmc)	550	800	1700	2000
Resonance Field H_r (Gauss)	2300	2300	500	500
Zero Field Loss	Low	Low	High	High
Apparent Density (g/cc)	5.0	5.1	5.0	4.9

The new ferrites are an addition to the Kearfott line which also includes high quality ferrites for broad band resonance isolators, X-band devices where high CM powers are involved, and other devices where high curie temperatures and low losses are required.

FOR MORE INFORMATION CIRCLE 83 ON READER-SERVICE CARD

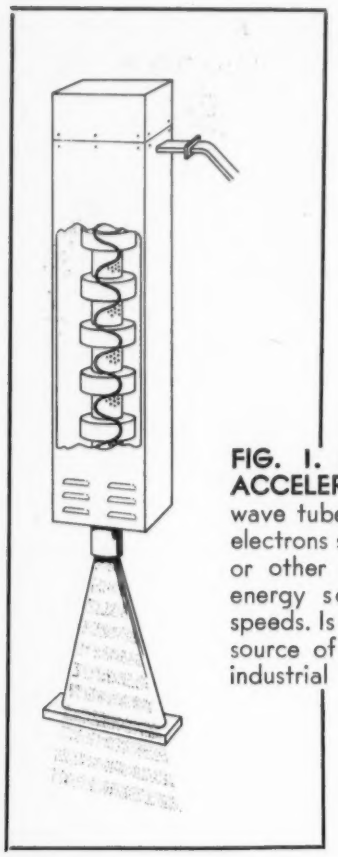


FIG. 1. MICROWAVE LINEAR ACCELERATOR uses travelling wave tube principle to accelerate electrons supplied from magnetron or other electron and pulsed-energy source, to relativistic speeds. Is a basic research tool and source of controlled radiation for industrial processing.

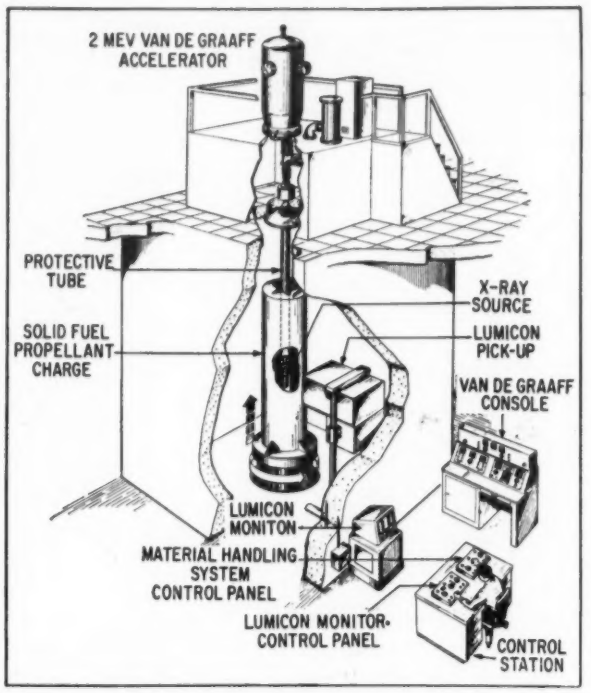


FIG. 2. X-RAY INSPECTION of Solid Fuel Rocket here shown uses Van de Graff accelerator, which would be replaced by similar use of Microwave Linear Accelerator for inspection of heavier missile engines. (Courtesy Aviation Week)

FIG. 3. 50-MEV Microwave Linear Accelerator designed by High Voltage Engineering Corporation for biological research at Argonne Cancer Hospital, Chicago, Ill.

The Microwave Linear Accelerator

ERVIN D. GANTT, High Voltage Engineering Corporation

THE MICROWAVE LINEAR Accelerator, a relatively new application of microwave energy, is increasingly important in many fields closely related to the military effort. This type of system, initially used only in fundamental physical and nuclear research, is now being used in missile engine and fuel inspection; solid-state research and development of new semi-conductor materials; sterilization of food, medical supplies, etc.; and is proposed for test simulation of Van Allen Belt radiation for the manned satellite program. Other uses now finding acceptance are in high energy therapy and cancer research. Its initial application, in the investigation of the fundamental nature of matter at energies up to hundreds of million electron volts, is being pushed in many laboratories.

The development of high powered radar tubes during World War II made practical the concept of the microwave linear accelerator. Another progenitor of the linear accelerator was the Van de Graaff accelerator which uses extremely high dc potentials to accelerate particles. In contrast with this principle, the microwave linear accelerator uses travelling waves of high frequency microwave (radar) power which are generated by a klystron or other pulsed source, and fired down an evacuated waveguide (Fig. 1).

Bunches of electrons fired into the waveguide are trapped by the electromagnetic fields associated with these waves and are accelerated to the speed of the wave itself. A rough analogy can be made to a surfboard rider being carried along on the crest of a rolling wave.

Generally speaking, the longer the waveguide, the greater the speed (and energy) of the electron beam produced. In Fig. 1 the sinusoidal wave can be considered as moving downward, carrying with it bunches of trapped electrons being accelerated to relativistic speeds. Focussing coils collimate the electron beam and direct it to the point of useful application.

With modern radar power tubes acting as the source of electrons and the generator of the travelling wave, accelerating waveguides of relatively short length are sufficient to achieve high beam energy power. Practical radiation processing of materials and deeply penetrating X-rays are thus made feasible.

While other types of accelerators have been used to accelerate protons, at present the microwave accelerator is limited to the acceleration of electrons. Since they travel in straight paths at approximately the speed of light no radiation is produced by the electrons themselves, and shielding of the electron stream is relatively simple. Also, no heavy and costly magnets are required in the microwave accelerator, as in electromagnetic particle accelerators. However, whenever the electrons strike a target, powerful X-rays are formed which must be appropriately shielded to protect operating personnel and other materials which should not be subjected to radiation. Poured concrete or solid concrete block walls from 1½ to 6 ft thick are recommended. Also basement or subterranean locations are preferred wherever possible. Special design of each application by experienced engineers is strongly recommended.

A typical use of High Voltage X-ray for the inspection of solid-propellant missiles is shown in Fig. 2. Although a Van de Graff unit is shown as the electron accelerator in this illustration, larger solid propellant sections require higher power electron sources for which linear accelerators are used. Non-destructive inspection to ensure homogenous construction of solid propellant grains is necessary to prevent malfunction at launching. Flaws in the charge, such as cracks or holes, can cause uneven burning capable of wrecking a launching station, or sending the missile off-course.

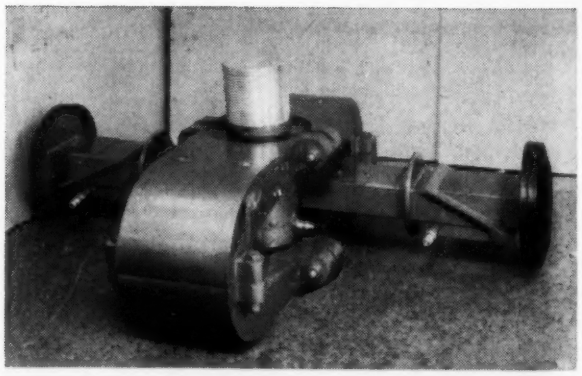


FIG. 4. THE AMPLITRON, an S-Band amplifier of Klystron or magnetron pulses, is capable of supplying 3 megawatts peak power for more powerful applications of Microwave Linear Accelerator in research and industry. The Amplitron is a development of the Spencer Laboratories, Raytheon Co., Burlington, Mass.

Medical applications, such as deep therapy by X-rays focussed on any desired location within the patient's body, and radiological treatment of tissues and laboratory animals in biological research, are facilitated by the microwave linear accelerator method which allows precise control of the high-energy radiation (Fig. 3).

The ionizing radiation produced by microwave linear accelerators is pure energy in its most fundamental form. Materials radiated at energies below 10 mev are generally free from radioactivity but sometimes strong ionization imparts new, desirable characteristics. This ionizing capability also lends itself to the testing of missile and satellite system components to detect degradation of performance which might result from radiation in the space environment, or in other environments where a radiation field is encountered—such as a nuclear reactor.

High power magnetrons and klystrons are generally used as microwave drivers for linear accelerators. Klystrons are frequently used in tandem with the second tube operating as an amplifier. Another microwave power amplifier is the Raytheon QK622 Amplitron (Fig. 4), recently developed under BuShips sponsorship.

The Amplitron uses a cathode assembly with a tungsten-thoria cermet emitter. Its heater is used only when the tube is being outgassed, as the tube can start and operate under "cold cathode" conditions. When the RF drive pulse is properly applied, residual gas molecules in the interaction space of the tube are ionized, are forcibly attracted to the cathode and initiate secondary emission at the cathode surface, thus maintaining operation. High efficiency, exceptional phase stability, low operating voltage and freedom from adjustment are advantages of the new tube.

The Amplitron has a normal gain of about 8 db in the 2900-3100 mc range. When operating at a peak RF power of 3 megawatts it is driven by a peak RF power pulse of 475 kilowatts, taken directly from a klystron or from another Amplitron driven by a magnetron or klystron. A high voltage pulse of 50 to 55 kv and 10 μsec duration is simultaneously supplied by a modulator.

CIRCLE 84 ON READER-SERVICE CARD

Modern Materials and Design Achiev

HIGHER RELIABILITY in motors for military applications is keeping step with the increased environmental hazards demanded by missile and space applications. The motor industry is devoting much of its time and effort to improving designs. These designs, together with improved materials, precise machining and exacting inspection, have increased motor life expectancy over ten times in the last few years. Long life expectancy is particularly important in military applications where servicing and down-time is a major consideration.

Modern motor and blower design has also made possible important weight and size savings in solid-state rectifier and transistor applications where small centrifugal or axial blowers replace less efficient convection cooling or heat sinks. In the case of one 200-ampere rectifier which weighed 38 lbs and used a heat sink, the substitution of an axial fan for cooling immediately reduced its weight to 28 lbs. By further design, a unit weighing only 17 lbs, but completely interchangeable with the 38-lb heat sink unit, was achieved.

FIG. 1. **ENVIRONMENTAL** conditions met in military applications are duplicated in Air-Marine Motors, Inc. Test Laboratory.

Environmental Tests Important

Environmental conditions met in the field are duplicated in the Air-Marine Environmental Laboratory (Fig. 1), where life tests as well as temperature, humidity, shock and vibration, salt spray and high altitude simulation are applied. In some cases life tests are performed after humidity cycling and other environmental tests; in other cases operating life tests are used, with comparable results.

Life tests on intermittent and continuous operation of subfractional horsepower ac motors from 1″ to 4″ diameter are run in the environmental ovens. Blowers designed to speed up at higher altitudes are checked both at sea level and in a vacuum equivalent to 70,000 ft altitude (Fig. 2). The results of this research have revealed many features essential to motor design for high reliability in rugged environments.

Long Bearing Life

Bearing failures, previously a prolific cause of motor failure, have been minimized by careful attention to the following features (Fig. 3):

Lubricants must be selected with operating temperatures and peripheral bearing speed. Thus, some of the silicone greases can be used to 3000 rpm in 1.0″ bearings but up to 11,000 rpm with a 0.5″ bearing of the same design. Because high peripheral speeds tend to degrade a lubricant, the recommendations of the motor manufacturer should in general be closely followed.

Concentricity of the airgap is necessary to avoid radial forces which are damaging to lubricants. Because of these and other variables, the concentricity of the stator bore to the rabbets and of the bearing bore to the rabbet must be precisely held.

Temperature Dissipation in bearing must be controlled by close and uniform contacts with press fit between bearing and shaft, and a slide fit between the outer race and the housing insert. This enables the smaller area to dissipate heat at a higher rate, tending to hold bearing temperatures uniform from inner to outer diameters. Also, the bearing must have a full seat rather than point or ring contact for proper alignment.

Rotor End-play and other axial pressures and vibrations are detrimental to bearing life. Proper shimming and/or spring loading are used to prevent rotor bind over the full range of operating temperatures.

Selection of Materials with particular attention to differences in coefficients of expansion between different types of steel, and between steel and aluminum can materially reduce bearing load variations due to expansion and contraction. Steel bearing inserts in aluminum housings are used to eliminate destructive pressures on the bearing at high temperatures. If the lubricant is decomposed by a hot spot its failure will damage the bearing before the pressure is great enough to directly cause bearing wear.

Contamination of the lubricant by dust, due to "breathing" of the motor as it heats and cools or encounters rapid changes in altitude in airborne service, can be minimized by providing proper air paths to equalize pressures and barriers around the bearings.

Stator Design Considerations

Long life under unfavorable environmental conditions also requires careful choice of materials and techniques in fabrication of the stator. Magnet wire insulation, slot liners and impregnating varnishes must be suitable for intermittent or continuous usage over the entire operational temperature range.

Teflon* and silicone wire insulation is generally indicated for high temperature applications, but because it has a high volumetric coefficient of expansion, Teflon must have sufficient room to avoid cold flow. Also, the abrasive quality of impregnating compounds and slot liners must be carefully determined because a slight movement is always present between coils when operating.

Room in the lamination slots must be adequate to eliminate the excessive pressures mentioned above. Also, in single phase motors, voltage across the capacitor phase must be held to a minimum. Care in design thus can prevent a common cause of winding failures.

Practical Temperature—Life Goals

A typical question asked by systems engineers is: "My application calls for an ambient operating temperature of 500 F. Can I use rotating equipment?" To this the answer is "Yes, because magnet wire and insulation materials have been developed for well beyond that temperature."

*Du Pont Trade Mark.

Continued on page 328

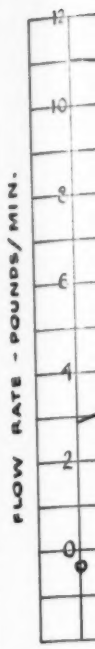


FIG. 2.
minute
cooling.

FIG.
pin-p

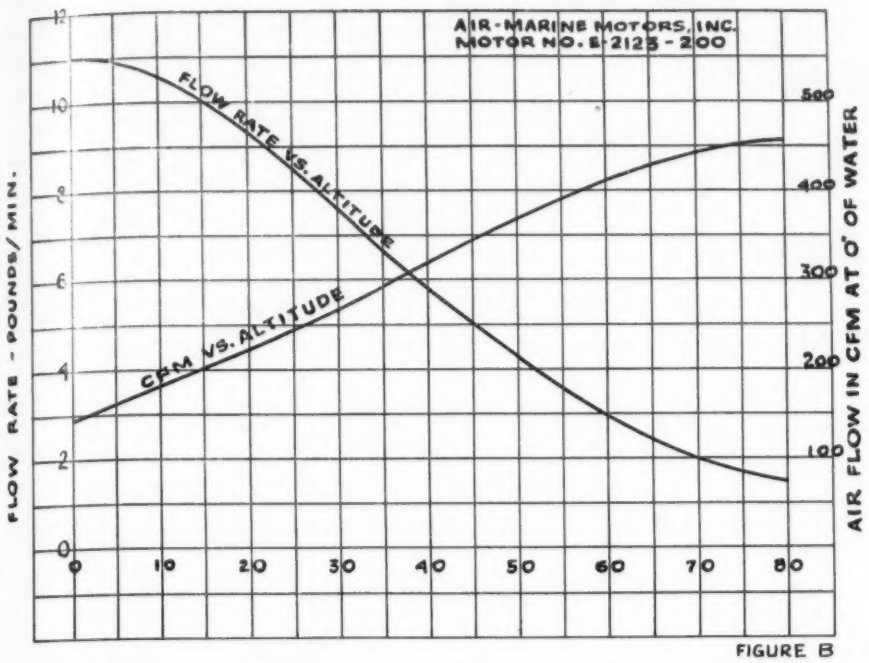


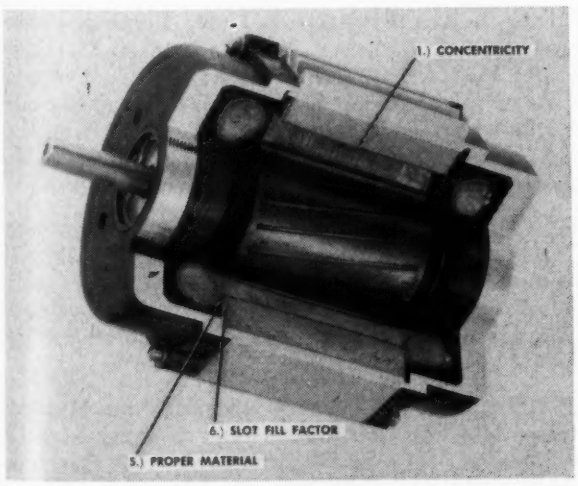
FIG. 2. **FLOW vs. ALTITUDE** in terms of volume-per-minute and weight-per-minute are both checked for aircraft type fans for electronic equipment cooling.

Motor Reliability

TABLE 1 MOTOR LIFE TEST RESULTS

Motor Dia. in inches	Ambient Temp.°C	Motor Rise°C	Total Temp.°C	RPM	Operating Time
1-3/4	85	36	121	11,750	7,000
1-3/4	30	28	58	23,500	[1]7,500
2	85	40	125	3,500	[1]16,000
2	55	47	102	7,000	19,000
2-5/16	25	75	100	3,600	[1]14,000
2-5/16	137	53	190	7,000	2,500
2-5/16	125	53	178	7,000	2,800
3-7/8	85	40	125	3,800	[1]11,000

[1]These units are still operating



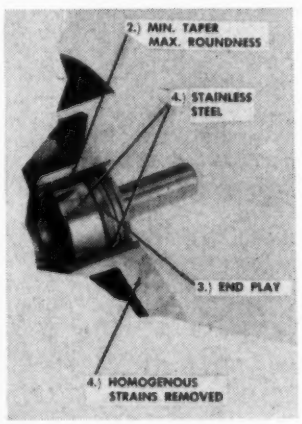
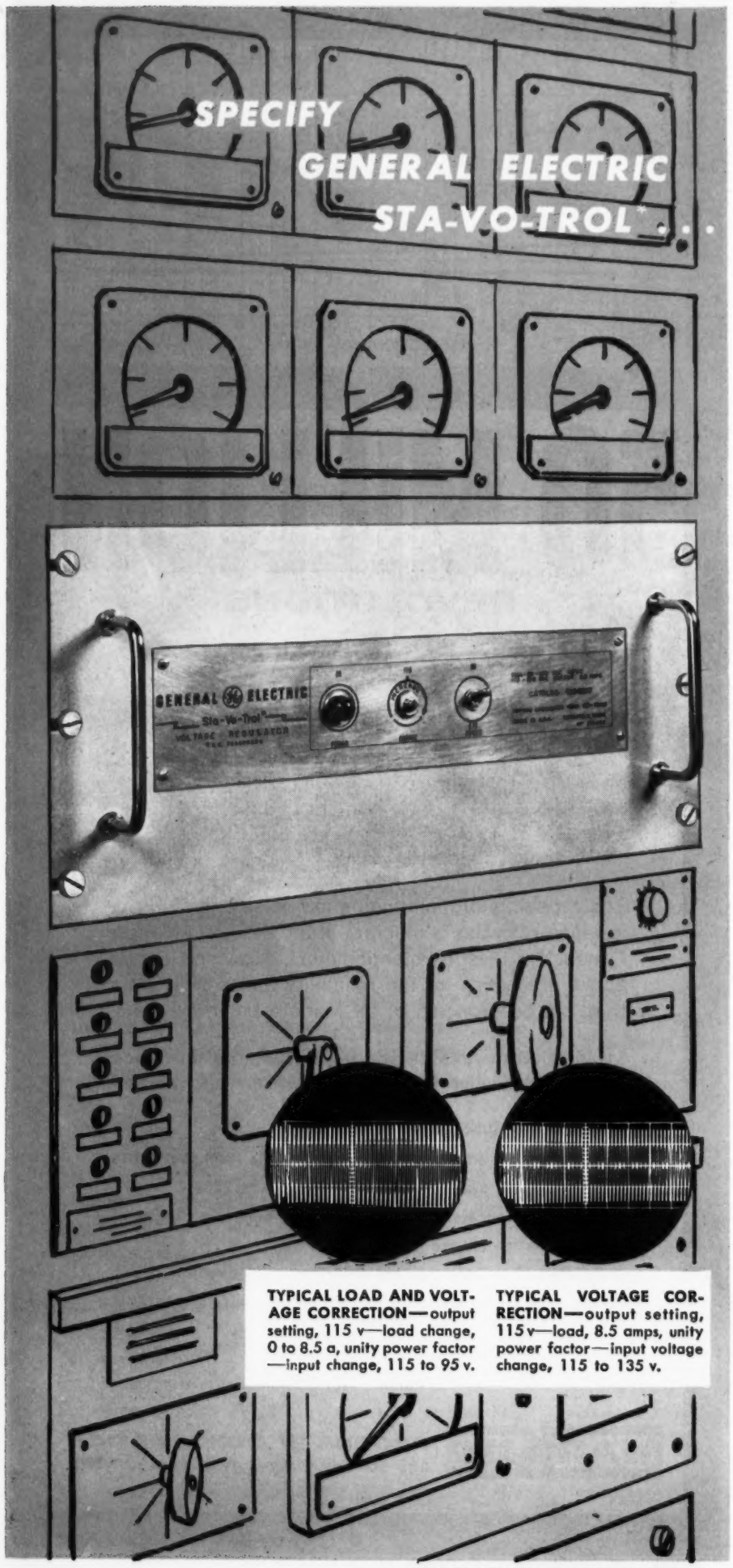


FIG. 3. **CRITICAL FACTORS** which affect motor reliability and life are pin-pointed in Air-Marine Motor design.



TYPICAL LOAD AND VOLTAGE CORRECTION—output setting, 115 v—load change, 0 to 8.5 a, unity power factor—input change, 115 to 95 v.

TYPICAL VOLTAGE CORRECTION—output setting, 115 v—load, 8.5 amps, unity power factor—input voltage change, 115 to 135 v.

New Static Voltage Control

For reliable automatic voltage control of critical loads

New General Electric Sta-Vo-Trol regulator gives you maintenance-free, automatic, *static* voltage control using unique rate feedback and industry-proven zener diode sensing.

Static components eliminate tubes, brushes, and other moving parts.

Sta-Vo-Trol regulators assure you reliable, constant voltage—regardless of line or load fluctuation—giving optimum performance of critical military and commercial electronic equipment.

Sta-Vo-Trol REGULATOR SPECIFICATIONS:

- Rating: 1 Kva output, 0 to 8.5 amperes, single phase, 60 cycles ±5%
- Input range: 95 to 135 volts
- Output range: 115 volts normal, 110 to 120 adjustable
- Accuracy: ±0.25% bandwidth†
- Response time: 6 to 12 cycles‡
- Load power factor range: 0.5 lagging to unity
- Wave-form distortion: 3%

† ±0.25% bandwidth for any line and load changes at constant power factor; ±0.5% bandwidth for changing load power factor.

‡ 6 to 12 cycles for 63% correction after ordinary line and/or load changes; up to 30 cycles for complete correction.

NET PRICE—$475
(type SLR-1000)

World-wide General Electric application and service facilities are available to you. For more information about the benefits of specifying G-E Sta-Vo-Trol voltage regulators for your application, write to Section 425-25, General Electric Co., Schenectady, N. Y.

* Trademark of General Electric Company for static voltage regulators.

Progress Is Our Most Important Product

GENERAL ELECTRIC

CIRCLE 29 ON READER-SERVICE CARD

When designing for such elevated temperatures, one should not expect to find a motor already developed for a specific application, and additional development must be expected. Standard bearings are usually no longer suitable. Also all problems encountered in normal application are magnified at higher temperatures. When seeking advice on unusual applications be certain your motor manufacturer knows *all* the operating requirements. Close cooperation between the motor engineer and the equipment engineer is extremely important when working near the limits of design capability.

Two typical examples will show what careful design can mean in actual hours of motor life. In both these cases, field and test reports before and after design are on file.

In the first case, a 2″ diameter motor driving a blower at 7000 rpm was being used to cool electronic gear. Specified ambient temperature range was −55° to 55°C with an operating life expectancy of 2000 hours. Air-Marine was asked to redesign for 10,000 hours. After complete redesign, reliability is high for 15,000 hours, and one unit has run over 19,000 hours in a 55°C oven.

In a second case, a 2½″ diameter motor driving a fan at 7000 rpm at sea level and at 16,000 rpm at 70,000 ft altitude operated between 500 and 1000 hours at 125°C ambient. After redesign this unit now passes 2500 hours under the same conditions.

Additional data taken on various motor frame sizes during life tests are shown in Table 1. Some of these longer life tests are still in progress, and additional high-temperature test results are not available in sufficient quantity to be conclusive. If motor failures are among your design problems, it will pay you to check the design date of your motor. It is highly probable that your difficulty will be solved by using a motor incorporating the latest materials and design features.

FOR MORE INFORMATION CIRCLE 85 ON READER-SERVICE CARD

BOOK REVIEWS

THE CATHODE RAY TUBE AND ITS APPLICATIONS, By G. Parr and O. H. Davie, Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y., (c1959) 433p., 5½″ x 8½″, $9.50. Third edition of standard work on cathode ray oscillography includes modern circuitry and applications of transducers, transistors and multigun tubes used in radio engineering, television and electromedical measurements.

SILICON ZENER DIODE HANDBOOK, Applications Engineering Dept., Semiconductor Products Division, Motorola, Inc., 5005 E. McDowell, Phoenix, Ariz., (c1959) 126 p., 5″ x 8½″, $1.00. First edition, covers basic theory, design characteristics and applications for voltage-limiting diodes.

UNDERSTANDING TRANSISTORS, by Milton S. Kiver, Allied Radio Corp., 100 N. Western Ave., Chicago 80, Ill., (c1959) 64 p., 6″ x 9″, $.50. Elementary treatise on transistor fundamentals and circuitry, including data on Knight transistor radio and test equipment kits.

15-Speed Oscillograph Transmission

RECORDING oscillographs, to attain the versatility demanded by modern applications, require a precise means of changing chart speeds. These chart speed changes must be carefully controlled because the accuracy of the recorded data is a function of chart speed.

In many oscillographs, 15 speeds are desired to permit a range from 0.070 ips to 170 ips paper speed. To obtain this range a gear transmission incorporating electrically operated magnetic clutches is used to select speeds.

Since it is necessary to have these speeds instantly changeable at the push of a button, an extremely rugged transmission design was mandatory. However, size was also an important factor inasmuch as the complete oscillograph must not be too bulky.

With the foregoing criteria in mind, Dynamic Gear Company, Inc., Amityville, N. Y. undertook to design a unit which would perform as required. The prime mover selected was a reversible commutating type ⅓ hp motor. This motor operates at 8500 rpm and is controlled very accurately by an attached governor.

To obtain chart speeds of 0.070 to 170 ips, it was necessary to use gear ratios giving from 3.3 to 7812 rpm in 15 increments. Previous designs had experienced trouble in maintaining sufficient torque at the high speeds. Also, small servo-type clutches which failed quickly under repeated switching had previously been used. For this reason, Dynamic Gear engineers exercised care in selecting a clutch that would not fail and would repeatedly deliver high torques throughout the life of the unit. Instead of the servo type clutch, one of the industrial types was selected. These units were found to be extremely rugged and no failures were experienced.

The gear materials are basically 2024-T4 Aluminum Alloy and corrosion resistant steel, type #303. The use of a nylon gear as quiet motor pinion was unsuccessful due to the high surface speed and low creep strength of nylon. However, the use of some gears made from a new DuPont plastic called Delrin has proved very satisfactory in reducing noise. For economic reasons it was necessary to use as few gears as possible and yet to very accurately maintain the required speed ratios. The ultimate 8-clutch design selected uses approximately 15 less gears than any previous design (Fig. 1). When the 15-speed transmission is in operation at a desired chart speed two clutches are simultaneously engaged. By electrically coupling various clutches together, any ratio in the desired range of 15 speeds is instantly obtained.

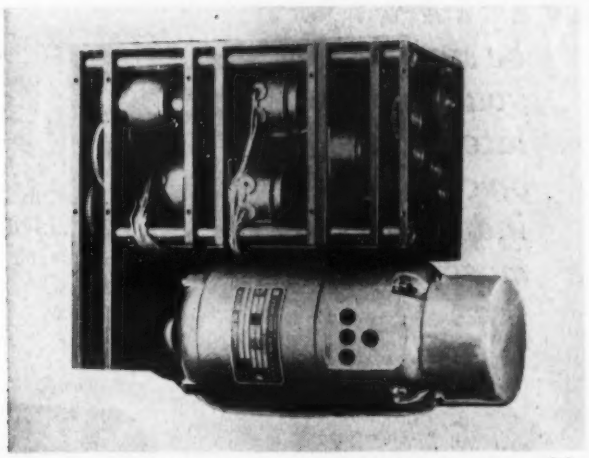
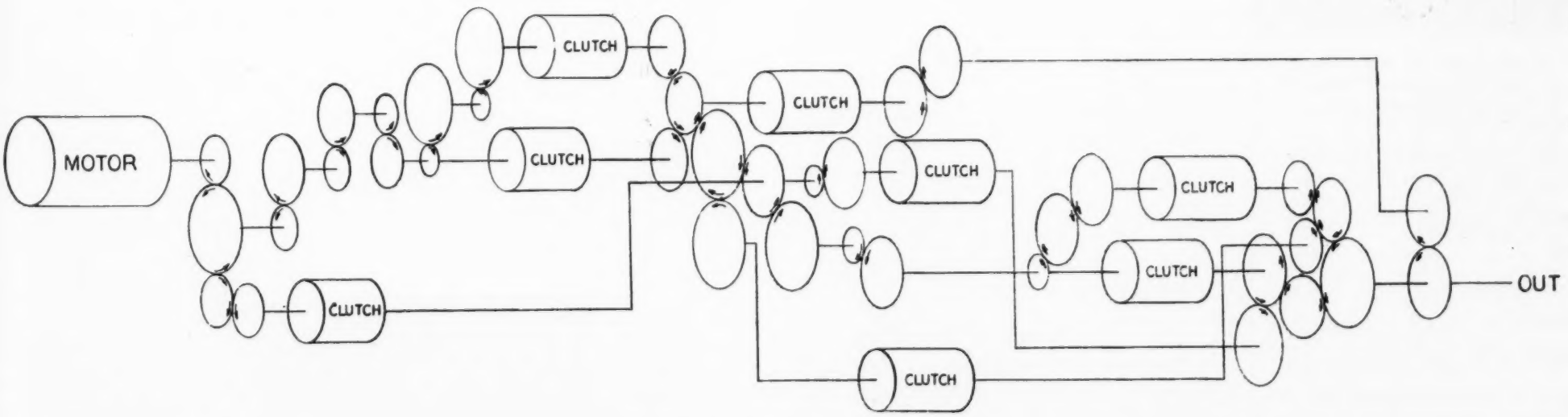


FIG. 2. RUGGED CONSTRUCTION increases life span five times over existing design.

Although the basic application for the 15-speed transmission is as an oscillograph drive, it is also useful in the laboratory in testing instrument packages. By using this device, equipment can be tested at various precise speeds which can be changed instantaneously at the touch of a button.

The unit operates on 60 or 400 cps at 115 v. Clutches operate on 28 vdc. Output torque ranges from 60 to 150 oz-in. Gears and shafting are corrosion resistant. Due to its extremely rugged construction, life of the 15-speed transmission is said to be five times greater than any other existing design (Fig. 2).

FIG. 1. LIGHT CLUTCH design uses 15 less gears than previous design.



High-Accuracy Pulse Power Calibrator

A precision instrument for measuring the instantaneous power in pulses of radio frequency energy to accuracy levels required by military specifications is now said to be available in the PCS-1 Pulse Power Calibrator developed by the General Communication Co., Boston 15, Mass., for production line or field use.

The unique method which assures secondary standard accuracy is based on an internal standard RF signal which is directly compared against the unknown pulsed signal on a cathode-ray tube. This RF reference signal is at the same frequency as the signal to be measured. Its power amplitude is standardized at each operation against a standard reference cell through precision resistors. An electronic notch-and-reference-line CRT display eliminates the need for external markings on the display tube or inaccuracies due to parallax in reading.

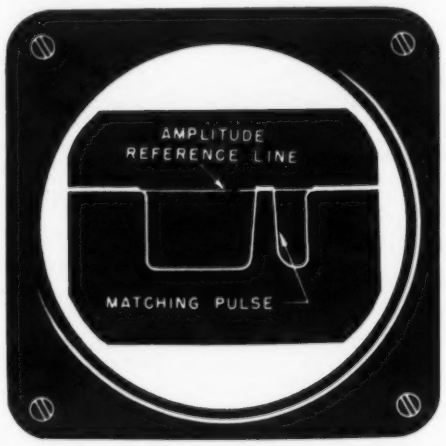


FIG. 1. CRT DISPLAY, showing Notch, Reference Line and Matching Pulse.

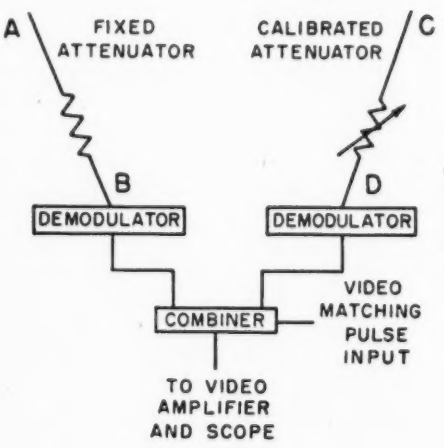


FIG. 2. SIGNAL Comparison Paths in Calibrator Circuit.

Theory of Operation

The power of the unknown pulsed signal is compared with a standard internal RF generator, operated at the frequency of the signal being measured at a

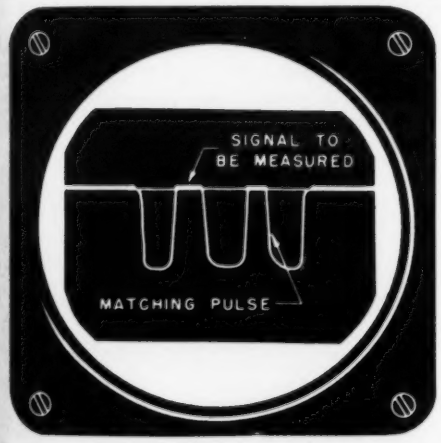


FIG. 3. COMPLETE CRT DISPLAY, Pulse Power Calibrator.

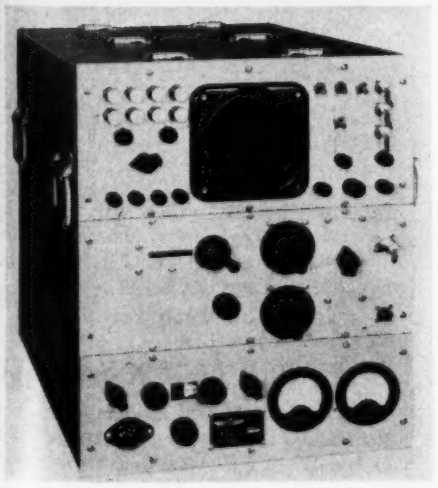


FIG. 4. PULSE POWER CALIBRATOR, PCS-1A.

level of 1 milliwatt. It is adjusted to this level by means of a precision bolometer bridge and standard potentiometer circuit. The accuracy of the bolometer bridge and potentiometer circuit permits setting the reference signal to an accuracy within ±0.05db.

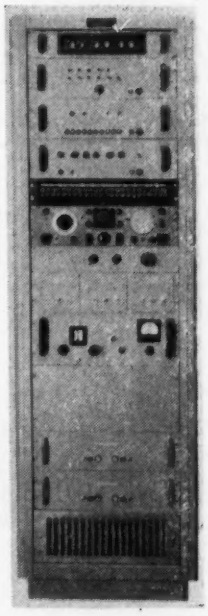
The cathode ray tube is swept twice for every trigger received. During the first sweep the standard generator is notched. The second sweep is unmodulated, producing the Amplitude reference line (Fig. 1). The Standard Notch signal determines the amplitude of the Notch. In order to equalize both branches of the signal comparison paths (Fig. 2) the standard signal is fed first through branch AB and matched against an internal video matching pulse (Fig. 1). It is then switched to path CD where the calibrated attentuator is adjusted to again match the video matching pulse. The dial of the calibrated attenuator is then set at zero, the standard signal returned to path AB and the instrument is ready for operation.

The display shown in Fig. 3 shows the Standard Notch with matching pulse reference and the signal to be measured after its height has been adjusted to exactly the amplitude reference line by means of the calibrated attenuator.

Model PCS-1A (Fig. 4), is now available in the 925-1225 mc range for peak pulse powers from —10 to 63 dbm. Similar units to cover the entire RF microwave spectrum are planned. (*From 4-page bulletin "Pulse Power Calibrator", General Communication Co., 677 Beacon St., Boston 15, Mass.*)

FOR THIS LITERATURE CIRCLE 87 ON READER-SERVICE CARD

Missile-Range Cadence Counter



Missile tracking ranges in many parts of the world are correlating test events to precisely measure missile position and performance by use of timing code signals from precision timing systems developed by Hermes Electronics, Inc., Cambridge, Mass. A typical Hermes system, Model 207, (here illustrated) consists of a 1 megacycle master oscillator of extremely high stability, a radio receiver for WWV Standard Time Signals, a comparator circuit for correcting drift error of the time base, and a number of time code generators for supplying specific time codes to magnetic or photographic data recording equipment.

Hermes Electronics engineers state that the Precision Timing System can be synchronized to within 100 microseconds of WWV, assuming that the radio propagation time is correctly calculated. Any number and type of timing code generators can be incorporated, each having the same precision as the master oscillator to which it is slaved.

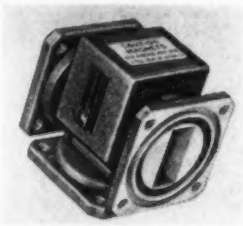
FOR MORE INFORMATION CIRCLE 88 ON READER-SERVICE CARD

MSD new products

MICROWAVE INSTRUMENTS & COMPONENTS

COMPACT CIRCULATOR TEE

New Model 380864-1A 3-port Tee rated at 50 kw peak and 50 watts average power is smaller and lighter than former models with less power.

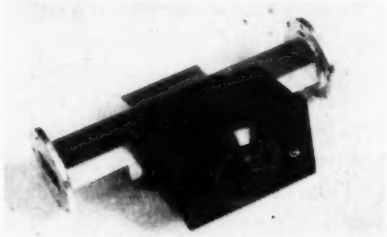


Provides isolation at 16 db min, input VSWR at 1.15 max, with insertion loss from antenna to receiver of 0.2 db max, over the 9.0 to 9.16 kmc range.—*Kearfott Co., Inc., Microwave Div., 14844 Oxnard St., Van Nuys, Calif.*

CIRCLE 89 ON READER-SERVICE CARD

WAVEGUIDE ATTENUATOR

Model RDA-5811 precision waveguide attenuator is adjustable from 0 to 40 db attenuation, accurate to 0.3 db at 4.8 kmc calibration frequency

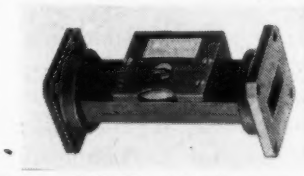


and to ±0.1 db from 0 to 1 db. Anti-backlash gear holds calibration over long periods; insertion loss 0.5 db, Max VSWR is 1.15.—*Radar Design Corporation, Pickard Dr., Syracuse, N. Y.*

CIRCLE 90 ON READER-SERVICE CARD

VARIABLE FIXED ATTENUATOR

Attenuations from 0.3 to 30.0 db over the 8.2-12.4 kmc range with a

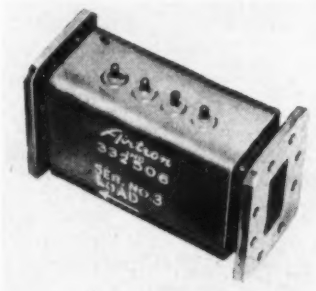


maximum VSWR of 1.15 are provided in unit constructed of RG-67/U waveguide, 3½" long. Dial setting locks in place.—*Waveline, Inc., Caldwell, N. J.*

CIRCLE 91 ON READER-SERVICE CARD

PHASE SHIFTER

New X-band phase shifter providing an electronically variable mismatch for frequency control of low-power magnetrons and klystrons uses ferrite rod in longitudinal field (Reg-

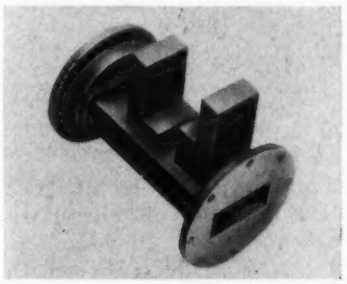


gia-Spencer technique). Max. 0.6 watts driving power provides ±45° minimum phase shift handling 2 Kw peak power. Other units in 3 to 36 Kmc range will be developed on request.—*Airtron, Inc. Div., Litton Industries, 336 No. Foothill Rd., Beverly Hills, Calif.*

CIRCLE 92 ON READER-SERVICE CARD

BAND PASS FILTER

A compact microwave filter consisting of a straight waveguide section with 4 E-plane cutoff stub arms on one wall with lengths selected to be resonant within the rejection band.



The design is applicable from 3 -36 kmc; initial C-band filter characteristics: Pass band insertion loss 0.3 db max; Pass band VSWR is 1.40 max; rejection in stop band is 30 db min and power handling capacity is 0.5 megawatt CW.—*Airtron, Inc., Div., of Litton Industries, Morris Plains, N. J.*

CIRCLE 93 ON READER-SERVICE CARD

PLANAR TRIODE CAVITIES

New line of Mercury '10' triode cavities engineered to 10% tuning range from 225mc up to high frequency limits of existing planar triodes meet MIL-E-5272 and MIL-E-5400 requirements. Each unit is custom assembled to specification, with 720 different models available.—*J-V-M Microwave Co., 9300 West 47th St., Brookfield, Ill.*

CIRCLE 94 ON READER-SERVICE CARD

MICROWAVE OSCILLATORS

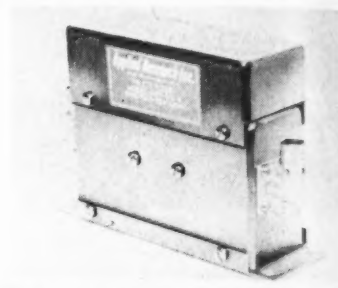
New QKK837 and QKK838 mechanically-tuned velocity variation oscillators cover the 67 to 73 Kmc

range with a minimum output of 10 milliwatts. RF output is through waveguide sealed by a mica window.—*Raytheon Company, Waltham 54, Mass.*

CIRCLE 95 ON READER-SERVICE CARD

BANDPASS RF FILTER

New Model HFF(C) filters for the 300 to 1000 mc range operate with 50-ohm input and output impedances.

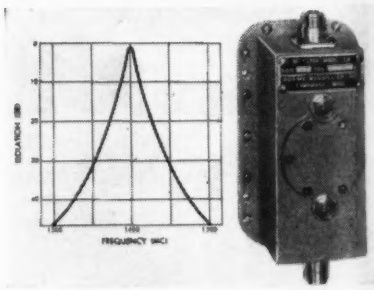


Typical unit operates at 332 mc with 3-db bandwidth of 24 mc, weight 20 oz.—*Applied Research Inc., 76 So. Bayles Ave., Port Washington, N. Y.*

CIRCLE 96 ON READER-SERVICE CARD

MIDGET CAVITY FILTER

New Model 410 dual Midget Cavity Filter for any frequency in the 400-2000 Mc range, is tunable over a



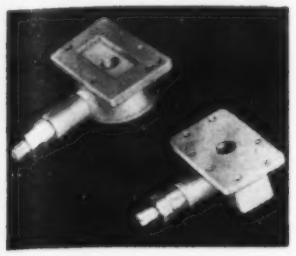
range of 3% to 10% at power ratings of from 20 to 50 watts depending on center frequency. Insertion loss 1 db.—*Adams-Russell Co., Inc., 200 Sixth St., Cambridge 42, Mass.*

CIRCLE 97 ON READER-SERVICE CARD

KLYSTRON CONTROL CAVITY

New cast Invar cavities for controlling frequency of transmitting klystrons to FFC specs, are now avail-

able for 5925-7750 mc range and can be designed for any frequency in L through Ku bands; are tunable over

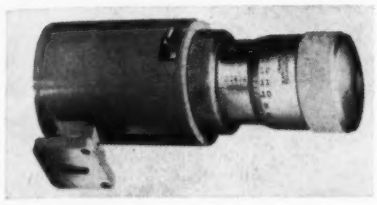


10% frequency range.—*Portchester Instrument Corp.*, 114 *Wilkens Ave., Port Chester, N. Y.*

CIRCLE 98 ON READER-SERVICE CARD

MICROMETER WAVEMETER

Secondary-standard wavemeters calibrated over the 2.6-140 Kmc range are equipped with micrometer heads, readable to 0.0001". High-Q accuracy

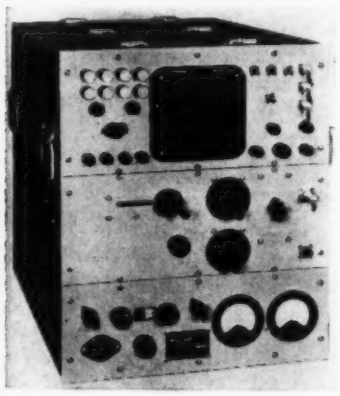


is maintained by sealed-in inert gas to withstand changes in humidity, altitude or barometric pressure.—*De-Mornay-Bonardi*, 780 *So. Arroyo Parkway, Pasadena, Calif.*

CIRCLE 99 ON READER-SERVICE CARD

PULSE POWER CALIBRATOR

New PSS-1 Pulse Power Calibrator compares signal amplitude to internally generated calibrated 1 mw



pulse. Has smaller proven max error than calorimetric method. Covers 925-1225 mc range.—*General Communication Co.*, 677 *Beacon St., Boston* 15, *Mass.*

CIRCLE 100 ON READER-SERVICE CARD

CURRENT PULSE GENERATOR

New 3000 Series pulse generators for use in design and test of current pulse driven devices have output rise time variable to 35 mμsec, peak amplitudes of 50 ma to 2.5 amp, and high source impedance. Produce vari-

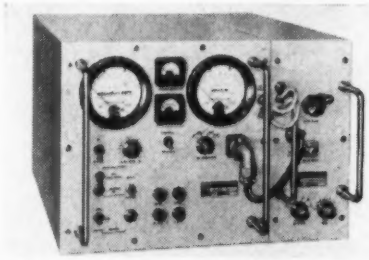
New Products—CONT.

able width, amplitude, and rise time outputs from external triggers at rates to 3 mc, or may be operated as an amplifier with output widths controlled by input signal durations.—*Electro-Pulse, Inc.*, 11861 *Teale St., Culver City, Calif.*

CIRCLE 101 ON READER-SERVICE CARD

STABLE SIGNAL TESTER

Stability of radar system signal sources such as stalos, cohos, klystrons, etc. can be checked either on the production line or while troubleshooting in the field for longterm

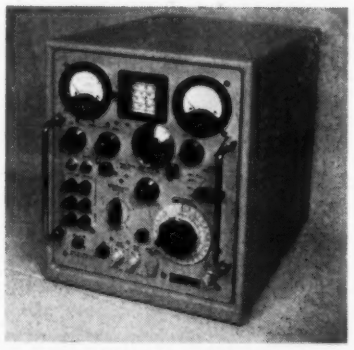


drift or short term deviation in the 1.1 to 10 Kmc bands using the Pitlog Series 800 Stalo Tester. Also provides output to Spectrum analyzer or oscilloscope for stability disturbance (FM) waveform.—*Pitometer Log Corp.*, 237 *Lafayette St., New York* 12, *N. Y.*

CIRCLE 102 ON READER-SERVICE CARD

VHF SIGNAL GENERATOR

VHF RF Signal Generator, model TS-510/U covering 10-420 mc in 5 bands, is designed for test, alignment and measurement of performance characteristics of VHF communications receivers. High stability, direct

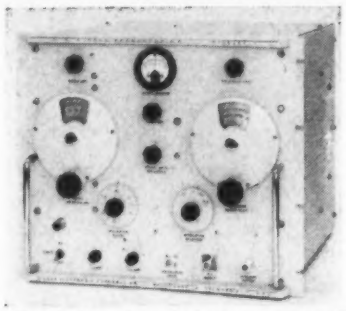


accurate calibration, broad modulation capabilities, microsecond pulsing, and low incidental FM are featured. All parts to MIL specs where applicable, with hermetically sealed meters, and moisture-fungus treatment.—*Nuclear Electronics Corp.*, 2925 *N. Broad St., Philadelphia* 32, *Pa.*

CIRCLE 103 ON READER-SERVICE CARD

UHF FM SIGNAL GENERATOR

Model 201B microwave signal generator for wide-band FM and as sweep generator for tuning and testing filters, etc., uses a reflex klystron in an external cavity. Calibrated piston attenuator provides excellent out-

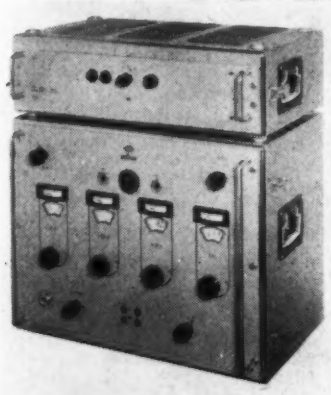


put linearity from 0 to −110 dbm over range from 1.3-3.5 kmc.—*Sierra Electronic Corp.*, 3885 *Bohannon Dr., Menlo Park, Calif.*

CIRCLE 104 ON READER-SERVICE CARD

FREQUENCY DECADES

Model Schomandl ND-5 Decade Generator provides discrete frequencies at 100 cps intervals from 50 cycles to 31 mc with max error of



1 cycle or 1/10 cycle. Model FD-3 provides frequencies between 300 mc and 10 Kmc with harmonic operation beyond 30 Kmc with accuracy of ±300 cps.—*Electronics Applications, Inc.*, 194 *Richmond Hill Ave., Stamford, Conn.*

CIRCLE 105 ON READER-SERVICE CARD

DELAY LINES

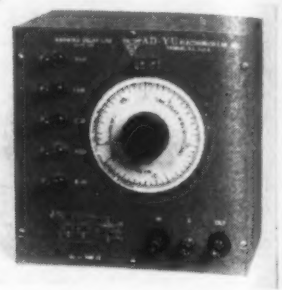
DELAY LINES

Precision lumped constant hermetically-sealed delay lines featuring low distortion and insertion loss are phase and frequency-compensated, using sub-miniature toroids and temperature-compensating disc capacitors, meet MIL specs. Design factors and data for special delay lines are included in 2-page data sheet.—*Valor Instruments, Inc.*, 13214 *Crenshaw Blvd., Gardena, Calif.*

CIRCLE 106 ON READER-SERVICE CARD

VARIABLE DELAY LINE

New continuously-variable delay lines Type 611a, and stepped 12-position Type 611b, with 611a providing fine resolution less than 8 x 10-11 sec and 611b giving a total delay to 32 μsec. Use over 150 sections of m-derived L-C networks to achieve min

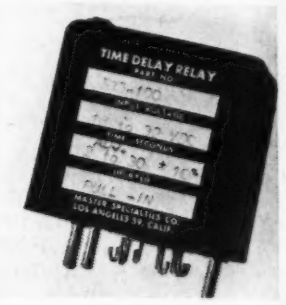


rise-time and overshoot.—*Ad-Yu Electronics Lab., Inc.*, 249-259 *Terhune Ave., Passiac, N. J.*

CIRCLE 107 ON READER-SERVICE CARD

ADJUSTABLE DELAY RELAY

New adjustable electronic time delay relay is internally set by external screwdriver adjustment of 45-turn

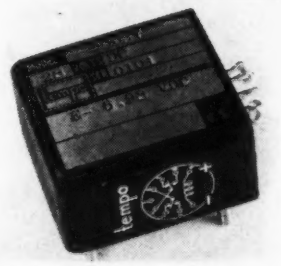


potentiometer to one of two ranges: 50 msec to 2 sec, or 2 to 50 seconds; for delay on either pull-in or drop-out.—*Master Specialties Co.*, 956 *East* 108*th St., Los Angeles* 59, *Calif.*

CIRCLE 103 ON READER-SERVICE CARD

VOLTAGE SENSOR RELAY

Model 90037 transistorized voltage sensor relay pulls-in when signal voltage reaches calibrated value (±5%); drops out when signal falls below



that value. Accuracy holds for any combination of rated shock, 50 G; acceleration or vibration, 20 G; ±10% supply voltage variation; and temp range of −55° to 100°C.—*Tempo Instrument Inc., P. O. Box* 338, *Hicksville, N. Y.*

CIRCLE 109 ON READER-SERVICE CARD

MICRO-MINIATURE RELAYS

New 700 Series relays using resilient bifurcated contacts include current- and voltage-sensitive, and mag-

netic-latching models. High level switching life at 2 amps resistive is 100,000 operations, with dry circuit

life at 5 million operations at 10 amp resistive.—*Iron Fireman Mfg. Co., Electronics Div., 2838 S. E. 9th Ave., Portland 2, Ore.*

CIRCLE 110 ON READER-SERVICE CARD

TELEMETERING COMMUTATOR

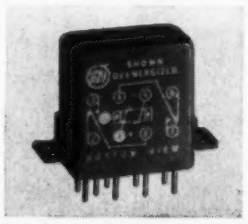
Model PDM miniature commutator provides 500-hr bounce and noise free service from 2-pole 45 BBM channel

20 rps non-shorting switch. One pole samples 900 single-ended transducer data sources/sec with transducer loading at less than 1 ohm and interchannel isolation at over 100 megohms. Second pole provides IRIG timing function. Complete specs in Tech Bulletin 500602.—*Instrument Development Labs., 67 Mechanic St., Attleboro, Mass.*

CIRCLE 111 ON READER-SERVICE CARD

SUB-MIN POLARIZED RELAY

New Series 33 subminiature polarized DPDT relay has immunity to vibration of 5000 cps at 30 G, shock and acceleration to 100 G. Standard



sensitivity of 200 mw over the −65° to 125° C range is provided in 2-position, magnetically biased operation.—*Sigma Instruments, Inc., 170 Pearl St., Braintree 85, Mass.*

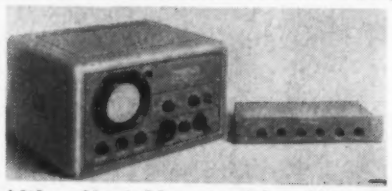
CIRCLE 112 ON READER-SERVICE CARD

SONIC ANALYZER AUXILIARY

New Auxiliary "C" unit for Model LP-1 Sonic Frequency Analyzer, provides variable operating parameters for high frequency resolution and

New Products—CONT.

measurement of noise waveforms, including continuously adjustable IF bandwidths, adjustable linear sweep

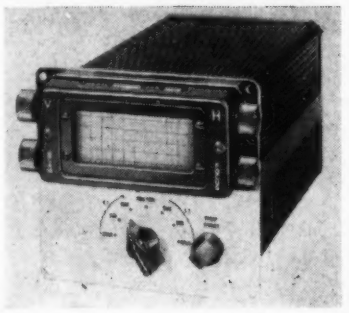


width, adjustable smoothing filter and voltage calibration reset.—*Panoramic Radio Products, Inc., 514 So. Fulton Ave., Mount Vernon, N. Y.*

CIRCLE 113 ON READER-SERVICE CARD

MINI CRT OSCILLOSCOPE

New Panelscopes, custom-designed for specific applications, provide miniaturized panel-mounting scopes for

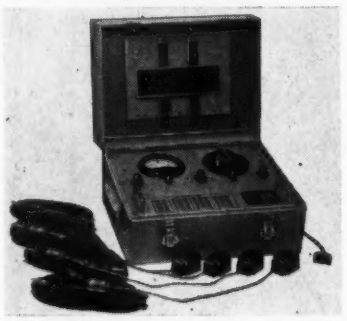


military field testing kits, system monitors, etc. with single knob control. JANized Model P1B2X8J is shown.—*Waterman Products Co., Inc., 2445 Emerald St., Philadelphia 25, Pa.*

CIRCLE 114 ON READER-SERVICE CARD

VIBRATION ANALYZER

Portable vibration analyzer designed to Buaer Specs for jet and turboprop engine, motor and gener-

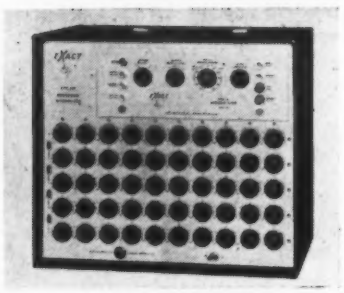


ator vibration tests uses 4 velocity type pickups calibrated to 1% accuracy. Powered by Ni-Cd battery with integral 115v ac charger.—*Sun Electric Corp., Harlem and Avondale Sts., Chicago 31, Ill.*

CIRCLE 115 ON READER-SERVICE CARD

WAVEFORM SYNTHESIZER

New Type 200 Waveform Synthesizer uses plug-in Type A variable slope and Type C variable width units



which can be independently varied to create any desired waveform.—*Exact Electronics, Inc., P. O. Box 552, Portland 7, Ore.*

CIRCLE 116 ON READER-SERVICE CARD

FREQUENCY STANDARD

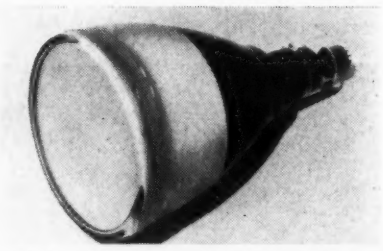
New 400 cps Vibra-Tine transistorized frequency standard is position-insensitive, also qualified to MIL-E-5272A. Consists of 1600 cps resonator

and flip-flop circuits, providing an output stable to 0.001% under vibration from 50 to 2000 cps up to 18 G, shock to 50 G and ambients from −20° to 70°C.—*Gyrex Corporation, 1654 Lincoln Blvd., Santa Monica, Calif.*

CIRCLE 117 ON READER-SERVICE CARD

TRANSISTOR-DRIVE CRT

New 12½" diameter Radar Display Tube, Type K1868, requires only 10v grid drive which can be furnished by



a single-stage transistor. Low capacitance beam modulating electrode permits wide band video information.—*Allen B. Du Mont Laboratories, Inc., 750 Bloomfield Ave., Clifton, N. J.*

CIRCLE 118 ON READER-SERVICE CARD

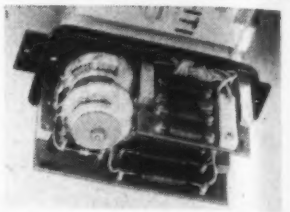
ANGLE DIAL READER

Precision semi-automatic reading of elevation-angle and azimuth-angle dials on cinetheodolite and radar data film is now possible by new reader. Dial images are projected on screen and angles from cross wire are semi-automatically punched into computer cards.—*Parabam, Inc., 13000 Yukon Ave., Hawthorne, Calif.*

CIRCLE 119 ON READER-SERVICE CARD

MINI-AMPLIFIER FOR OSCILLOGRAPHS

New instrumentation drive amplifier to permit application of low level

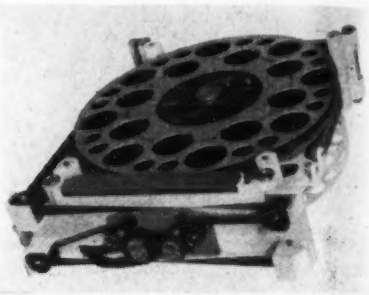


signals to direct-writing pens is said to be six times smaller than previously available models and adaptable to any oscillograph data recorder.—*Special Products Div., Leach Corp., Compton, Calif.*

CIRCLE 120 ON READER-SERVICE CARD

ASTRONAUT'S TAPE RECORDER

New Magnetic tape recorder, loaded with 4800 ft of ½" tape, records 8 hrs of continuous voice plus six other



channels of instrument data from man in orbit vehicle. Loaded weight, including electronics, is only 12 lbs.—*Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.*

CIRCLE 121 ON READER-SERVICE CARD

TELEMETRY PREAMPLIFIER

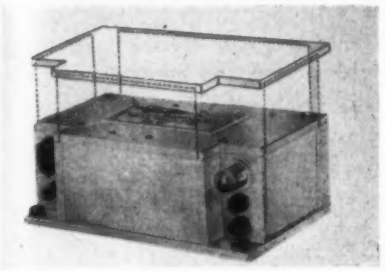
New Model TP-4 telemetering preamplifier, designed to operate from a 50-ohm source, has 22 db gain, 4 db max noise figure and covers the

215-260 mc telemetering band. Is enclosed in weatherproof housing with self-contained power supply for antenna tower mounting.—*LEL, Inc., 380 Oak St., Copiague, L. I., N. Y.*

CIRCLE 122 ON READER-SERVICE CARD

FM TELEMETERING TRANSMITTER

Model 1483-A1 true FM telemetering transmitter is completely modularized with all circuits on individual bulkheads for separate replacement

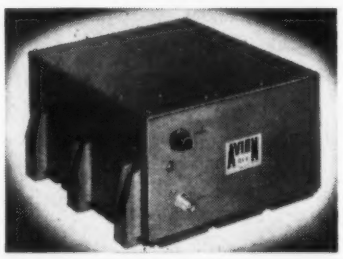


and easy maintenance. Output is 2 to 6 watts, 215 to 260 mc, withstands environmental missile conditions and temperatures over 100°C.—*Telechrome Mfg. Corp.*, 28 *Ranick Drive, Amityville, N. Y.*

CIRCLE 123 ON READER-SERVICE CARD

TRANSISTORIZED BEACON

New Radar Beacons (C- and S-band) Type 149, designed as missile-borne pulse-type tracking aid for

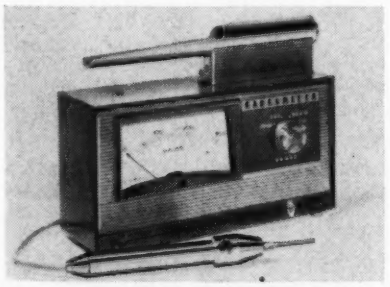


long-range missile and space application is transistorized except for LO and transmitter. Operates on 24 v dc.—*Avion Div., ACF Industries, Inc.*, 11 *Park Place, Paramus, N. J.*

CIRCLE 124 ON READER-SERVICE CARD

DIRECT-READING GAUSSMETER

New Model 100 Gaussmeter uses thin wafer of high-purity indium arsenide only 0.019" thick and 0.125" wide, permitting insertion into very

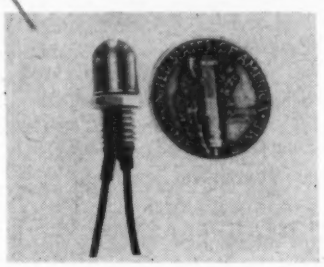


narrow air gaps. Sensing element uses Hall-effect principle, does not disturb field being measured. Selectable scales permit maximum readings to 300, 3,000 and to 30,000 gauss. Reads dc flux only even in a strong ac field.—*F. W. Bell, Inc.*, 1356 *Norton Ave., Columbus* 8, *Ohio.*

CIRCLE 125 ON READER-SERVICE CARD

MINI INDICATOR LIGHT

New series L10000 moisture-proof indicator lamp equipped with threaded anodized case mounts in clearance hole for #10 screw. Lens available

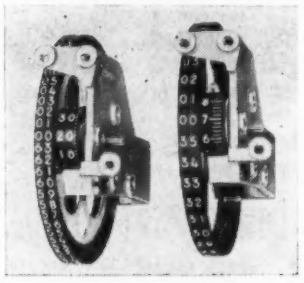


in colors. Draws 0.060 amp at 5v dc for life of 60,000 hrs.—*Hetherington, Inc.*, 1420 *Delmar Drive, Folcroft, Penna.*

CIRCLE 126 ON READER-SERVICE CARD

PRECISION COUNTER

New simplified mil-spec precision counters count non-decimal systems of units such as hours, degrees, mils, minutes, etc. with return-to-zero and

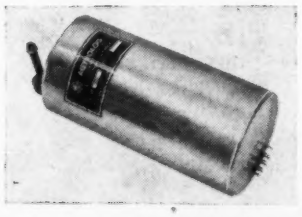


repeat. Type 1400 degree counters read through 359.9° to 0° then repeat with clockwise rotation, subtract with counterclockwise rotation.—*Chicago Dynamics Industries, Inc., Precision Products Div.*, 1725 *Diversey Blvd., Chicago* 14, *Ill.*

CIRCLE 127 ON READER-SERVICE CARD

ALTITUDE CONTROL SERVO

Model 904 transistorized altitude controller operating from 28v dc gives 400 cps output signal proportional to altitude for control purposes. Operates in closed loop mode until refer-



ence altitude is reached when "Altitude Hold" signal is activated, decoupling servo motor from gear train. System then operates open loop with deviations in altitude being sensed by the pickoff, amplified and supplied as control voltage to the autopilot.—*Metrolog Corp.*, 169 *N. Halstead St., Pasadena, Calif.*

CIRCLE 128 ON READER-SERVICE CARD

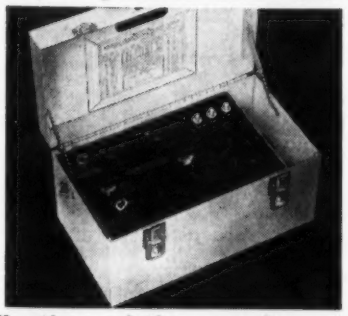
ELECTROSTATIC LENS

New Electrostatic Strong-Focusing Lens for use with Van de Graaff, and Cockcroft-Walton accelerators, clycotrons, and other ion accelerators can focus an ion beam 15 to 20 ft from image of the analyzing magnet. The unit cancels the normal astigmatism produced by the focusing action of the magnet. Lens flanges supplied to fit purchaser's system.—*Texas Nuclear Corp., P. O. Box 9267, Austin, Tex.*

CIRCLE 129 ON READER-SERVICE CARD

FUEL GAGE TESTER

Type 1429-A Fuel-Gage Tester (Military designation TTU-68/E Tester) is precision instrument for



calibrating aviation capacitance-type fuel-gage systems, smaller and lighter than previous models.—*General Radio Co., West Concord, Mass.*

CIRCLE 130 ON READER-SERVICE CARD

INCH-LONG SERVO

New size 5 servo motor for extremely compact servo mechanisms delivers a no-load speed of 9500 rpm;

has stall-torque of 0.09 oz-in with input of only 3.5 w. The 400 cps unit operates over ambients from −55° to 150°C.—*IMC Magnetics Corp., 570 Main St., Westbury, N. Y.*

CIRCLE 131 ON READER-SERVICE CARD

HI-TEMP SERVO MOTOR

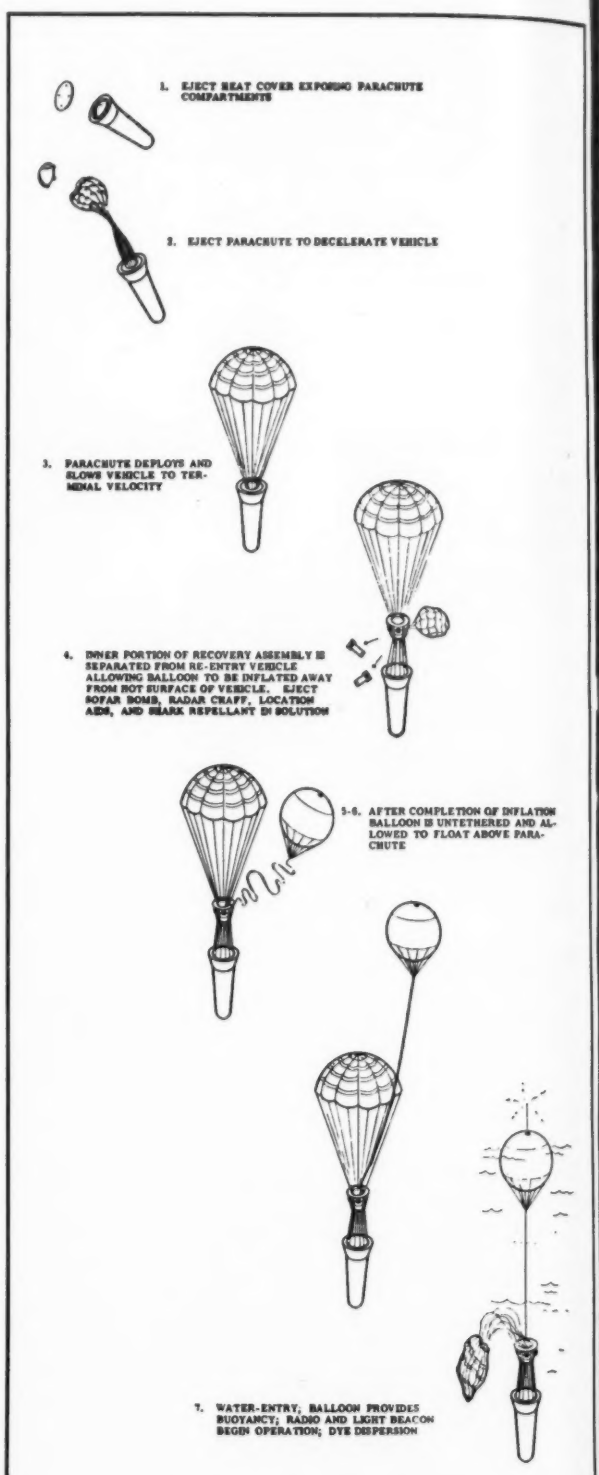
New size 15 high-temperature inertial damped T1311-22 servomotor operates over temperatures from −55° to 200°C with a no-load speed

of 45 rpm and a stall-torque of 1.45 oz-in. Operates at 115 v, 480 cps on fixed phase and on the series-connected control phase.—*Kearfott Company, Inc., 1500 Main Ave., Clifton, N. J.*

CIRCLE 132 ON READER-SERVICE CARD

Re-entry Vehicle Recovery System

Recovery is very desirable for the ablating type nose cones tested in the Thor-Able program. In contrast to the "heat sink" design, these ablating vehicles



are designed so that their surface vaporizes under the heating of re-entry. How much of this material has vaporized, and from what parts of the surface the vaporization has taken place is of extreme interest to

designers, and, although much of this data can be measured and telemetered, the best information is obtained by physical recovery of the vehicle itself.

Following separation of the nose cone from the booster stages after powered flight, the re-entry vehicle continues in trajectory for hundreds of miles into space. Upon reaching its apogee, the re-entry vehicle begins the return to earth and is subjected to extremely high deceleration and heating.

During the descent of the vehicle, illustrated in the Figure, a deceleration switch is used to actuate a timer and initiate the recovery operation. At an altitude of about 20,000 feet, the rear cover of the re-entry vehicle is ejected, and a drag parachute is mortared through this opening to decelerate the vehicle from supersonic to subsonic velocity. At subsonic velocity, a final descent parachute is used to slow the vehicle to a safe impact velocity. An impact velocity of from 60 to 100 miles per hour is considered satisfactory for the water recovery of instrumented payloads.

A flotation system contained within the recovery package is inflated from high pressure air containers prior to water impact and outside the vehicle shell since, at this stage, the vehicle surface is still extremely hot. The flotation balloon is made up of a rubber bladder inside a rubberized nylon outer casing.

During the descent, prior to water impact, a sofar bomb is ejected and falls free into the water. After sinking to a predetermined depth, this bomb is detonated, giving off signals that enable listening stations to triangulate its position. Also, radar chaff is ejected to give an indication of its location to search aircraft in the impact area.

After impact on the ocean, a water activated battery turns on a radio beacon and a flashing light. Dye, carried around the flotation balloon, dissolves, leaving a slick on the water. These signals aid the trained search team aboard ships and aircraft in locating the vehicle prior to recovery.

The initiation and reaction of each step in the recovery sequence is completely automatic and requires a reliable programming system. Components which sense changes in missile environment, such as acceleration, both axial and lateral, pressure, and temperature were developed. In all cases dual circuitry is incorporated to provide for adequate reliability.

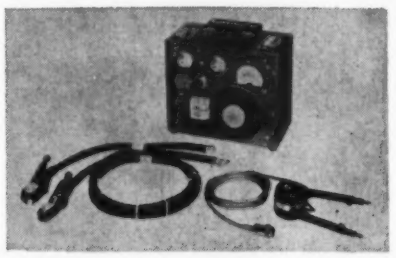
The actual programming of the complete recovery sequence is controlled by a very accurate mechanical timer. This timer is the "brains" of the recovery system. It acts to initiate the various phases of the recovery sequence so that the vehicle structure will not be overloaded during parachute deceleration, that the flotation system will be inflated before water impact, and that location aids are operating properly to permit rapid recovery of the vehicle.

(*From two 8-page brochures: "Thor-Able Re-entry Vehicle Recovery System" and "Thor-Able and Atlas Re-entry Recovery Programs", by Missile & Space Vehicle Dept., General Electric Co., Philadelphia 4, Penna.*)

FOR THIS LITERATURE CIRCLE 133 ON READER-SERVICE CARD

ANTI-EXPLOSION BRIDGE

New Model T207 Michrom Bridge (Bonding Meter) measures low resistance bonding in hazardous fuel tank, fuel cell, aircraft areas with

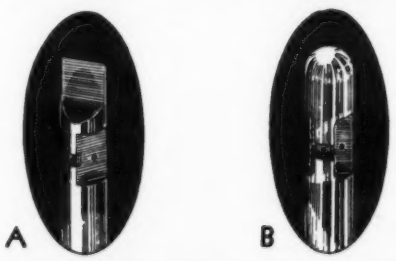


no danger of explosion. Maximum voltage outside vapor-tight housing is 0.055 v ac, is powered from internal flashlight cells.—*Avtron Manufacturing Co., 10409 Meech Ave., Cleveland 5, Ohio.*

CIRCLE 134 ON READER-SERVICE CARD

VELOCITY PROBES

Two new velocity measuring probes are said to be useful in measuring velocity and flow in both liquids and gases. Both can be made as small as ⅛" diameter and are individually

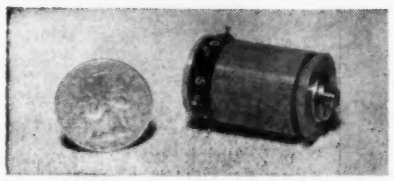


calibrated. The pitch-insensitive probe (A) ignores pitch angle up to 15° from normal to the probe axis but measures total pressure, static pressure and yaw angle, 3-dimensional probe (B) carries five pressure orifices to determine total pressure, static pressure, yaw angle and pitch angle at any point in air stream.—*United Sensor & Control Corp., Box 127, Glastonbury, Conn.*

CIRCLE 135 ON READER-SERVICE CARD

POTENTIOMETER-CLUTCH

New Model 120 is single unit comprising precision film potentiometer, 1000 to 200,000 ohms, and a minimum



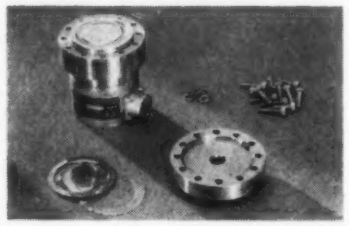
torque clutch providing engagements under 20 msec and speeds up to 1000 rpm.—*Computer Instruments Corp., 92 Madison Ave., Hempstead, L. I., N. Y.*

CIRCLE 136 ON READER-SERVICE CARD

New Products—CONT.

LOW PRESSURE TRANSDUCER

New Model 227 Teledyne pressure transducer designed for quick response (1 msec) measurements of

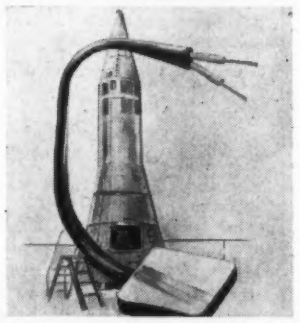


corrosive and dynamic fluid or gas pressures to 50 psi provides pressure cavity cleanout, also repeatability within 0.1% of full scale and linearity to less than 0.3% of full scale. —*Taber Instrument Corp., Section 242, No. Tonawanda, N. Y.*

CIRCLE 137 ON READER-SERVICE CARD

MISSILE THERMOMETERS

"RdF Stikon" and "Strapon" resistance thermometers used to meter missile shroud temperatures in suc-

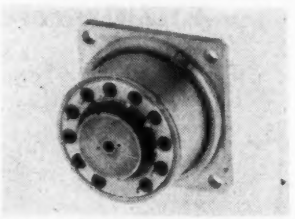


cessful flight of NASA Juno II rocket are also available for many other essential temperature measuring jobs.—*Arthur C. Ruge Associates, Inc., Hudson, N. H.*

CIRCLE 138 ON READER-SERVICE CARD

LINEAR ACCELEROMETER

New miniature precision accelerometer type TA-400 for measuring linear acceleration in missiles and aircraft, is said to withstand 100G shock

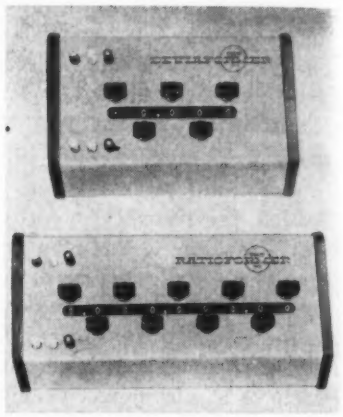


and 20G vibration over 50-2000 cps. A new suspension system and a pick-off which uses superimposed dc or ac excitation are two new features unique to the unit which has an accuracy of ½% of full scale.—*Components Div., Fairchild Controls Corp., 225 Park Ave., Hicksville, L. I. N. Y.*

CIRCLE 139 ON READER-SERVICE CARD

VOLTAGE RATIO TESTER

New Deviaformer with digital in-line readout of percent of deviation from specified voltage ratios, used



with OECO Ratioformer providing precision ac voltages, gives go, no-go testing for production of transformers, synchros, resolvers, computers and meters.—*Osborne Electronic Corp., 712 S. E. Hawthorne Blvd., Portland, Ore.*

CIRCLE 140 ON READER-SERVICE CARD

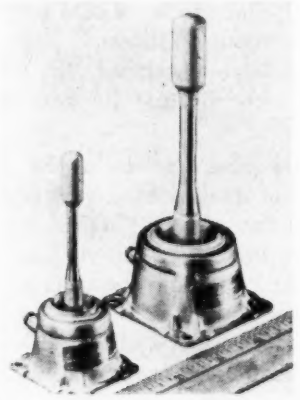
BREADBOARD SERVO

New Gap "Servo Construction System" enables use of standard servo components in prototype or full production assemblies by use of accurately-machined gears, mounting plates and other kit parts. 12-page brochure illustrates method, lists components. —*Gap Instrument Corp., 116 Merrick Rd., Freeport, L. I., N. Y.*

CIRCLE 141 ON READER-SERVICE CARD

HI-INTENSITY MICROPHONES

Two High-Intensity microphones, NM 125 and NM 135, meeting different frequency response and size requirements, use self-generating

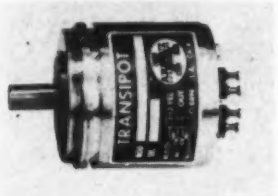


ceramic sensors with operating temperature range of −60° to 260°C, and withstanding other extreme environments. Linear dynamic measurement range is 95 db to 200 db.—*B & K Instruments, Inc., 3044 West 106th St., Cleveland 11, Ohio.*

CIRCLE 142 ON READER-SERVICE CARD

LINEAR MOTION TRANSDUCER

New Size 15 Transipot ac/ac variable reluctance transformer is furnished for 26 v, 400 cps input in 20,

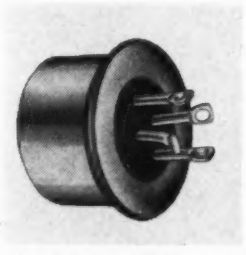


50 and 100 mil ranges. Sensitivity, 1 v rms/mil; output impedance, 1000 ohms; linearity 0.5% usable frequencies 300-3000 cps.—*Arnoux Corporation*, 11924 *W. Washington Blvd., Los Angeles* 66, *Calif.*

CIRCLE 143 ON READER-SERVICE CARD

THREE-PHASE THERMOSTAT

New Klixon 2862 Series thermostats are snap-acting, hermetically sealed, fixed temperature controls designed for use in 3-phase wye-connected circuits. Are factory preset to

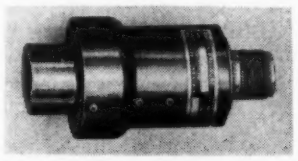


open and close within a nominal 20°F differential within the —65° to 300°F range. Contacts are rated at 208/115 v 60-400 cps, 10 amps resistive for 600 operating cycles.—*Metals & Controls Div., Texas Instruments, Inc.*, 34 *Forest St., Attleboro, Mass.*

CIRCLE 144 ON READER-SERVICE CARD

PRESSURE SWITCH

New low cost pressure switch, factory set to actuate at any point from 0.5 to 4,000 psi, is resistant to water-alcohol, nitric acid and hydrogen peroxide, and operates over —65° to

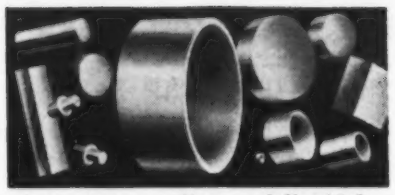


300°F range. Series 1580 switch meets aircraft, missile and rocket hydraulic and pneumatic requirements.— *Haydon Switch, Inc., Waterbury* 20, *Conn.*

CIRCLE 145 ON READER-SERVICE CARD

CERAMIC TRANSDUCERS

New type US500 ceramic transducer element which has high stability up to 300°C is said to be superior to barium titanate crystals for sensor and high-power driver elements in



underwater sounding and liquid level sensing gages.—*U. S. Sonics Corp.*, 625 *McGrath Highway, Somerville, Mass.*

CIRCLE 146 ON READER-SERVICE CARD

DISPLACEMENT GYRO

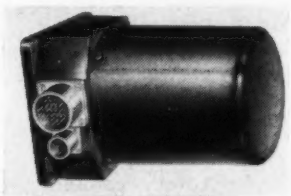
New Cageable free gyro with potentiometer or synchro signal pickoff provides accurate angular intelligence

for control or telemetering. Caging and uncaging is electrically accomplished by motor or solenoid. Complete technical information available. —*Whittaker Gyro Div., Telecomputing Corp.*, 16217 *Lindbergh St., Van Nuys, Calif.*

CIRCLE 147 ON READER-SERVICE CARD

DE-ICING TIMER SWITCH

Forty leading-edge de-icing circuits (plus 20 supplemental circuits) are consecutively energized in pairs



through multi-pole snap switches for four complete cycles, eliminating heavy and costly relays frequently used.—*Bendix-Pacific Div., Bendix Aviation Corp.*, 11600 *Sherman Way, No. Hollywood, Calif.*

CIRCLE 148 ON READER-SERVICE CARD

NPN POWER TRANSISTOR

New NPN diffused junction silicon transistors are rated at 50 watts at 25°C mounting flange temperature.

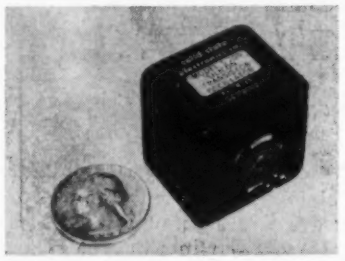
Types 2N1069 and 2M1070 are suited for switching applications, dc amplifiers and Class A and B power amplifiers.—*Silicon Transistor Corp., Carle Place, N. Y.*

CIRCLE 149 ON READER-SERVICE CARD

New Products—CONT.

SINUSOIDAL OSCILLATOR

New Model S-200 silicon transistor sinusoidal oscillator in epoxy encapsulated unit provides a stable

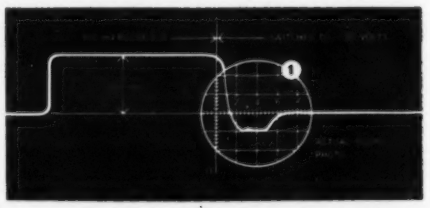


frequency output for telemetering and instrumentation from 25 cps to 100 kc. Each oscillator draws 1 ma at 28 v dc.—*Solid State Electronics Co., Sepulveda, Calif.*

CIRCLE 150 ON READER-SERVICE CARD

HIGH-SPEED DIODE

New 1N690/693 Series Silicon Switching diodes, available in four voltages, effect 0.8 μsec switching of

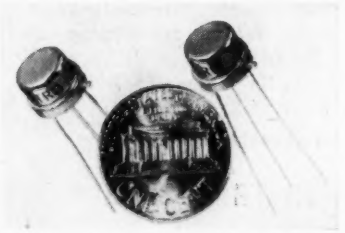


½-amp pulses for computer applications. Complete specifications on request.—*Sperry Semiconductor Div., Sperry Rand Corp., So. Norwalk, Conn.*

CIRCLE 151 ON READER-SERVICE CARD

INSULATED TRANSISTOR

Type 2N1356 PNP germanium alloy transistor is improved, reliable replacement for Type 2N396A except



that all leads are insulated from case, eliminating possibility of contact "shorts" caused by "hot cans" touching. Meets MIL-Specs.—*Industro Transistor Corp., 35-10 36th Ave., Long Island City 6, N. Y.*

CIRCLE 152 ON READER-SERVICE CARD

5-WATT HF TRANSISTOR

High-Power (5-watt) 30 mc silicon transistor for output stage of radio transmitters operates from mercury cells in mobile Citizens "D" band or Military rescue applications.—*Pacific Semiconductors, Inc., Culver City, Calif.*

CIRCLE 153 ON READER-SERVICE CARD

Aircraft 3-ø to DC Converter

Modern aircraft power supply design which takes full advantage of improvements in silicon junction rectifier and transformer-iron characteristics is portrayed in the new static converters developed by the Electrosolids Corporation, Panorama City, Calif., which change three-phase 400 cps power to highly stable dc power with full-load efficiencies approaching 95%.

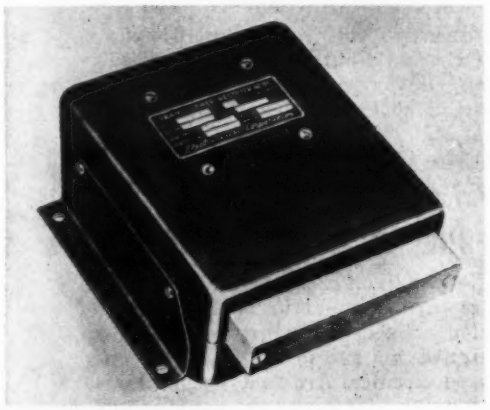


FIG. 1. LIGHTWEIGHT aircraft-type construction eliminates heavy castings, provides efficient cooling, in new Power Supply design.

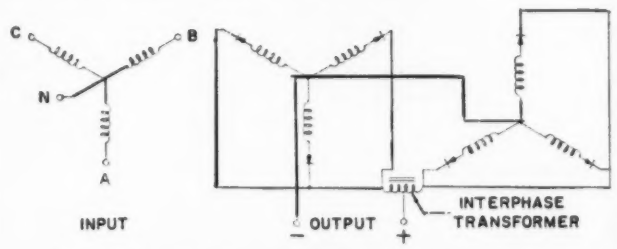


FIG. 2. WYE-WYE INTERPHASE circuit reduces ripple to 5%, gains improved thermal efficiency.

Because new PN junction silicon diodes provide significant savings in size and weight over the selenium rectifiers previously available, a redesign program in transformers, packaging, circuits and cooling was instituted. This review has resulted in units which weigh only 25% of the original selenium-transformer units and which occupy only 15% of the original volume.

Optimum-shaped transformer cores, high-temperature insulating materials and the use of silicon transformer steel with preferred-grain orientation account for a large part of the savings in size and weight. Lightweight construction of the package in which the stressed-skin cover carries the load is another weight saving factor. (Fig. 1). The circuit (Fig. 2) capitalizes on the high reverse voltage ratings of the silicon rectifiers, which allows the use of half as many rectifier units as would be necessary in the conventional bridge circuit. The circuit also has rectifier current ratings 40% better than the six-phase star circuit.

The Wye-wye interphase output circuit is essentially two 3-phase star rectifiers which are 60° out of phase electrically, paralleled through an isolating

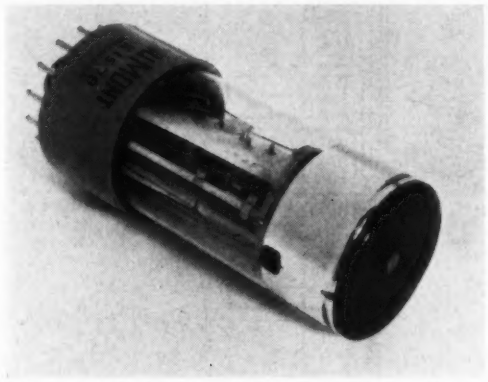
reactor. The objective of the reactor is to isolate the two circuits from each other so that for AC each operates independently from the other. With the isolation provided, each arm of the rectifier conducts current for ⅓ cycle. Since the heating effect of an intermittently flowing current of a given average value decreases as the duty cycle increases, it is highly desirable that the current flow be maintained for as long a portion of the cycle as possible. Thus the isolation provides for a reduction in required current rating to approximately the square root of the ratio of the conduction times, or $(1/6 + 1/3)^{½} = (1/2)^{½} = 0.707$ for square waves (0.60 for sine waves). This circuit has a maximum ripple of 5% which is readily reduced by standard filtering if desired.

(*From* 12-page *Engineering Bulletin "Aircraft Converters—3-ϕ AC to DC". Electrosolids Corporation, 13745 Saticoy St., Panorama City, Calif.*)

FOR THIS LITERATURE CIRCLE 154 ON READER-SERVICE CARD

Multiplier Phototube Detects Neutron Flux

A new neutron detector tube which can be used with standard multiplier phototube circuitry has been developed by the Electronic Tube Div., Allen B. DuMont Laboratories, Inc. Designated the type K-1578, it is a 2" diameter, end-window 10-stage multiplier tube.



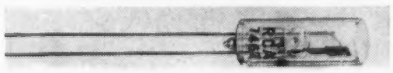
NEUTRON DETECTOR has high sensitivity to thermal neutrons.

A neutron sensitive coating is first applied internally on the window, followed by a standard S-11 cathode deposit. A neutron striking the window is captured and ejects an alpha particle and a negative ion, with very high energies. These particles and ions impinge on and penetrate the neutron sensitive coating and the S-11 cathode which in turn eject secondary electrons. The secondary electrons are directed into and multiplied in the high-gain multiplier structure like photoelectrons. Because the initial surface is especially sensitive to thermal neutrons it can discriminate between these and gamma radiation and high-speed neutrons. When calibrated against a standard thermal neutron source it can be used as a quantitative detector. Applications as a neutron leak detector in cyclotron or other types of fission research are anticipated. Complete specifications are available from the *Electronic Tube Sales Dept., Allen B. DuMont Laboratories, Inc., 750 Bloomfield Ave., Clifton, N. J.*

FOR THIS LITERATURE CIRCLE 155 ON READER-SERVICE CARD

PHOTOJUNCTION CELL

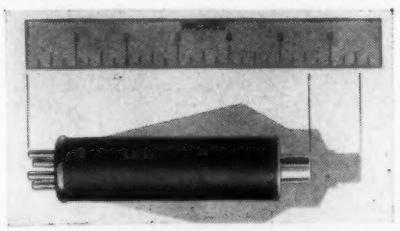
Small side-on cell employing germanium p-n alloy is intended for sound pickup from film and for computer applications. Features sensitivity of 0.7 uamp/foot-candle and fast rise and decay characteristics.—*Electron Tube Div., Radio Corp. of America, Harrison, N. J.*



CIRCLE 157 ON READER-SERVICE CARD

SILICON RECTIFIER

Type S-5130 Silicon Rectifiers replace 866 type mercury vapor tubes plugging into socket, but requiring no filament power or warmup time. Operate in 100° ambients to 10,400 v PIV on continuous loads of 300 ma resistive-inductive.—*Sarkes Tarzian, Inc., 415 No. College Ave., Bloomington, Ind.*



CIRCLE 158 ON READER-SERVICE CARD

HI-CURRENT FAST RECOVERY DIODE

New silicon diode types 1N837 thru 1N845 have minimum forward currents of 100-200 ma. Such high forward currents are generally obtained at the expense of the diode recovery time, which in this case has remained at 0.3 to 0.5 μsec, permitting higher energy clock circuits with greater reliability for diode-logic elements.—*Semiconductor Div. Hughes Aircraft Co., P. O. Box 278, Newport Beach, Calif.*

CIRCLE 159 ON READER-SERVICE CARD

15-MC SILICON TRANSISTOR

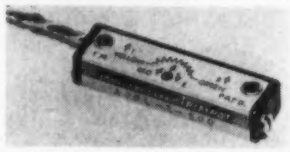
Four new high frequency NPN silicon transistors for general purpose amplifier and switching use are JEDEC TO-5 types 2N1276 to 2N1279 inclusive. Fixed-bed design, which mounts transistor pellet on ceramic disc on floor of housing, is said to give operating range of −65° to +200°C. Minimum alpha cutoff frequency is 15 mc, 1000-cycle power gains are from 37 to 45, and typical output capacity C_{ob} is 2 μμf. Operates on 40 v collector-to-base voltage.—*General Electric Co., Semiconductor Products Dept., Charles Bldg., Liverpool, N. Y.*

CIRCLE 160 ON READER-SERVICE CARD

New Products—CONT.

RANGES INCREASED

New resistance ranges for Model 200 Trimpots cover 10 to 100K ohms in 0.1 oz, ¼ watt size. Resolution is



said to be down to 0.17% with mechanical life over 25,000 shaft revolutions.—*Bourns, Inc., P. O. Box 2112, Riverside, Calif.*

CIRCLE 164 ON READER-SERVICE CARD

MULTITURN POTENTIOMETER

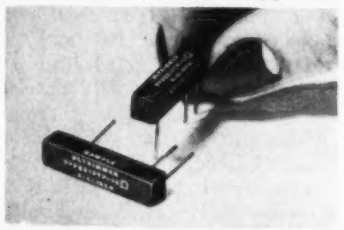
New Series 450 MULTIPOT 10-turn units are available in ¾" diameter and in resistance ranges from

1000 to 250K ohms. Rated 2½ watts, they operate from −65° to 100°C and withstand shock of 20G, 11 msec. —*Daystrom Pacific,* 9320 *Lincoln Blvd., Los Angeles* 45, *Calif.*

CIRCLE 165 ON READER-SERVICE CARD

TRIMMING POTENTIOMETER

New printed circuit trimming potentiometer in ranges from 200 to 150,000 ohms can be supplied for



transistor circuitry with a high positive temperature coefficient.—*Ultronix, Inc.,* 111 *E 20th Ave., San Mateo, Calif.*

CIRCLE 166 ON READER-SERVICE CARD

PLASTIC-CASED CAPACITORS

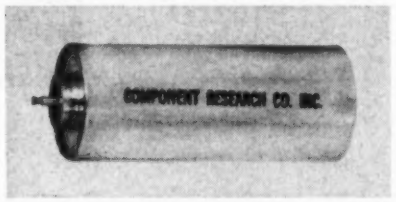
New "Polycap" capacitors with solid impregnant affording long life, high insulation and low power factor char-

acteristics are free of any outer wax coating and uniform in appearance. Complete technical specifications available.—*Aerovox Corporation, New Bedford, Mass.*

CIRCLE 167 ON READER-SERVICE CARD

STABLE CAPACITOR

New Type CFT Teflon Dielectric Capacitors having low temperature coefficient with less than 0.06% capacitance change from −10° to 85°C

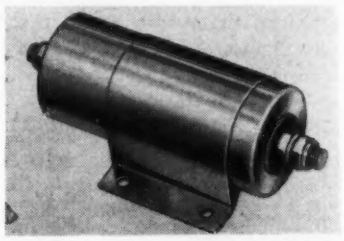


and retrace within 0.02% have insulation resistance over 10^{13} ohms from 25° to 85°C.—*Component Research Co.,* 2639 *So. La Cienga Blvd., Los Angeles* 34, *Calif.*

CIRCLE 168 ON READER-SERVICE CARD

RF INTERFERENCE FILTER

Missile system radio interference filter rated at 150 amp 100 v dc has overload capacity to 300 amp for 1



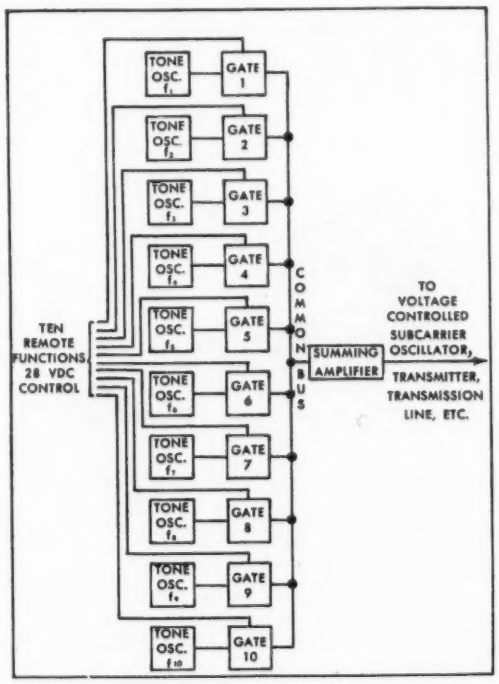
hr at 125°C. Meets MIL-M-8069 and MIL-T-6181B.—*Genistron, Inc.,* 2301 *Federal Ave., Los Angeles* 64, *Calif.*

CIRCLE 169 ON READER-SERVICE CARD

Eleven-Tone Telemetering System

A new eleven-tone telemetering system, totally transistorized with rugged high-temperature silicon transistors, has been announced for use with existing and planned FM-FM telemetering systems. Designed to indicate the precise occurance and sequence of remote functions through catastrophic environmental extremes, it is a product of the Solid State Electronics Co., 8158 Orion Ave., Van Nuys, Calif.

The standard unit, designated Model T-108, contains 11 sinewave oscillators (Fig. 1) each controlled through a gated switch. Any or all gates may be opened simultaneously, allowing the respective oscillator outputs to appear on the common bus of the summing amplifier where they are mixed. The composite signal is amplified and may then be fed to a transmission line or to a voltage-controlled subcarrier oscillator for conversion to FM within any specified IRIG band. The advantages and fidelity of FM transmissions over long distances are well known.



The tones generated may range from 25 cps to 100 kcps and are held to a bandwidth tolerance of ±5% under all specified conditions. Tone schedules should be set up with adjacent tones selected so that each frequency f_n is not greater than 0.83 f_{n+1}. At the receiver, individual tones are separated and the intelligence decoded. Operating from a nominal 28 v dc supply, it draws a current of only 20 ma.

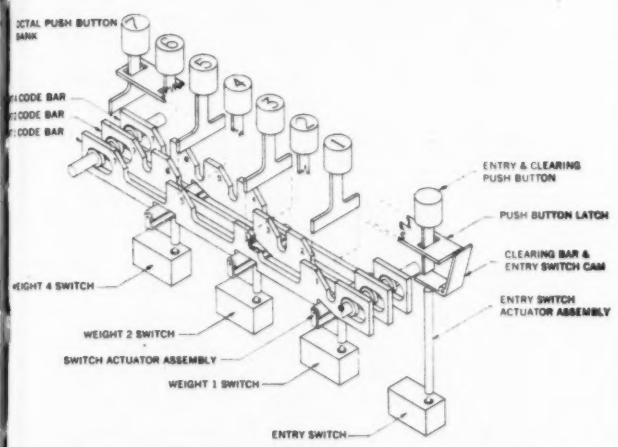
An interesting application of the composite tone method is in the parallel transmission of binary data over a single transmission link, thereby increasing intelligence transmission rates. The transistorized rugged construction of the T-108 tone generator enables it to withstand shock to 150 G and vibration to 2000 cps at 35 G. Frequency drift is stable to 0.05%/°C from −25° to 100°C and to 0.05%/volt from 23 v to 33 v dc supply voltage. Its high reliabil-

y under wide variations of environment, plus its ry small size and light weight (3.7 lbs) minimize lemetering problems in missile and space vehicle ap- lications, while its trouble-free long life recommends for industrial telemetering and control use, accord- g to its developers.

OR MORE INFORMATION CIRCLE 170 ON READER-SERVICE CARD

Code Bar Computer Switch

A new code bar switch provides a direct binary ded output from reliable mechanically-linked push ttons without resorting to multiple relay contact rrangements formerly required. As shown in the dia- ram, an octal push button bank utilizes three coding witches and one entry switch which is actuated by e clearing key.



CODE BAR SWITCH provides direct binary coded utput from four double-throw Micro Switches.

Examination of the figure shows that depressing the No. 1 key actuates the weight 1 code bar, which in urn actuates the weight 1 switch. Pushing the No. 3 ey drives the weight 1 and weight 2 code bars for- ard simultaneously actuating the weight 1 and weight switches. Similarily, pushing the No. 7 button ac- uates all three code switches.

All switches are Micro Switch Model V3-19 double- hrow having contact ratings of 6 amperes at 30 v dc, 0 amperes at 115 v ac. A mechanical interlock per- mits only one key to be depressed at a time, eliminat- ng any possible ambiguity, and banks of keys can e stacked to form complete keyboards. In addition o the Model OS-2 shown—eight-button Octal bank ith zero, or "clear" pushbutton with 1-2-4 binary utputs plus a single pole double throw switch coupled o the zero (clear) pushbutton—a Model OS-1 (same rrangement without double throw switch) and a Model DS-1 (full ten-button decimal bank with 1-2-4-8 inary outputs) are available.—(*From 4-page bulletin CBS-1, "Code Bar Switches," Computer Control Co., Western Division, 2251 Barry Ave., Los Angeles 64, California.*

FOR THIS LITERATURE CIRCLE 171 ON READER-SERVICE CARD

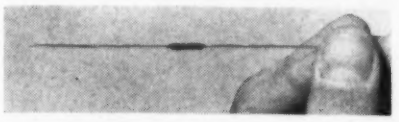
SUBMIN PULSE TRANSFORMERS

Type AME Pulse Transformers wound on high mu ferrite cup cores encapsulated in ½" long aluminum cases come in a range of pulse widths from 0.05 to 5.0 μsec and with operating temperature ratings to 150°C—*Technitrol Eng. Co., 1952 E. Allegheny Ave., Philadelphia 34, Pa.*

CIRCLE 172 ON READER-SERVICE CARD

MICRO WIREWOUND

New RS-½ wirewound resistor with a rating of ½ watt up to 75°C ambient is only 0.338" long x 0.071" diameter. Available in 1 ohm to 6K

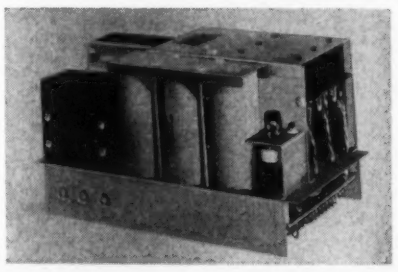


ohms, and tolerances in six degrees from 0.05 to 3%. Temperature coefficient is 20ppm. over range from —55°C to 275°C.—*Dale Products, Inc., Columbus, Nebr.*

CIRCLE 173 ON READER-SERVICE CARD

POWER MODULES

Two Transistorized DC Power Supply Modules providing outputs from 5 to 32 v dc and up to 6 amperes



can be combined in parallel input (105-125 v, 60 cps) series output, to give up to 64 v.—*Dressen-Barnes Corp., 250 N. Vinedo Ave., Pasadena, Calif.*

CIRCLE 174 ON READER-SERVICE CARD

REGULATED D-C SUPPLY

New Model MTRO36-5 0-36 v dc laboratory power supply is said to combine reliability of magnetic amplifiers for static power regulation with quick-acting transistor circuits

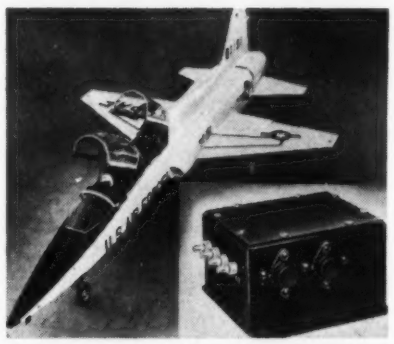
for transient line and load changes. Protects voltage-sensitive transistorized loads against damaging overshoots, with dynamic load regulation to 0.2v for step changes from no-load to full-load or vice versa.—*Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif.*

CIRCLE 175 ON READER-SERVICE CARD

New Products—CONT.

SOLID STATE INVERTER STARTS JETS

New Model SIS-W41251 solid state inverter converts 18-24 v dc to 100-145 v, square wave 320-360 cps source for starting jet engines of the T-38

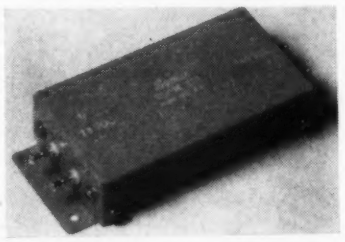


Air Force trainer either on the ground or in the air after flameout.—*Magnetic Amplifiers, Inc., New York 55, N. Y.*

CIRCLE 176 ON READER-SERVICE CARD

KEEP ALIVE SUPPLY

New Model BL-N-004 keep-alive supply provides ionizing potential of

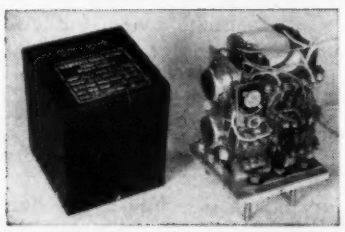


750v dc at current of 170 μamp. Output voltage variation is regulated to ±3% between 22 and 34 v input.—*Bomac Laboratories, Inc., 1 Salem Rd., Beverly, Mass.*

CIRCLE 177 ON READER-SERVICE CARD

MINI POWER SUPPLY

New Model 7PVR20 transistorized supply with output of 100 v at 40 ma dc, uses input of 115v ±10% at 400 cps. Output voltage is constant



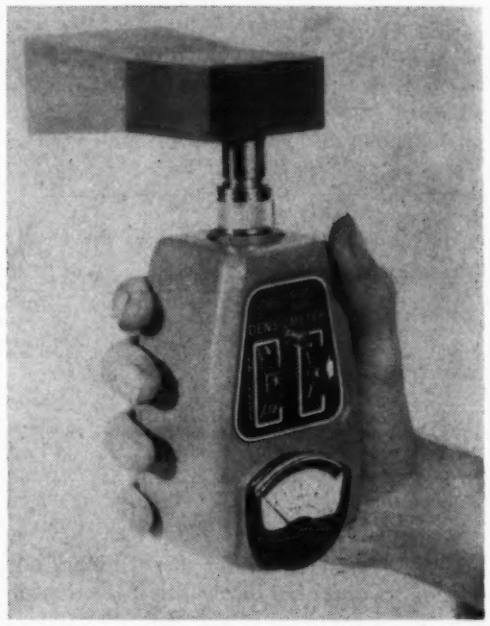
within ±03% from no-load to full load current, and for 10% input voltage variation. Output voltage varies only ±½% under temperature change from −40° to 165°F.—*Western Gear Corp., P. O. Box 182, Lynwood, Calif.*

CIRCLE 178 ON READER-SERVICE CARD

Densiometer Protects Workers From RF Field Injury

Medical investigation, it is said, has shown that high levels of short-wave radiation, such as produced by radar, act much the same as diathermy waves used by doctors for deep heat treatment of muscles and tissues. Exposure to high levels of such radiation can cause severe burns and related physical damage to tissue, eyes and other organs.

It is also believed that the effects of such exposure are often gradual, building up over a period of time. For this reason the hazards can be especially dangerous to workers whose jobs expose them daily to such radiation, whereas a single exposure for only one day may not prove harmful.



RF POWER Monitor, the Model 1200 Densiometer, measures radio field intensities harmful to personnel. Can be used by inexperienced worker, is also useful as a quick test for radar transmitters.

Protection from these effects is afforded by a new RF power meter (see Figure) designed to enable non-technical personnel to map any areas of radiation intensity which exceed a level of 10 mw/cm², which is the presently accepted highest safe level. The Model 1200 Densiometer, a product of the Radar Measurements Corporation, Hicksville, N. Y., is said to be as easy to use as a photographer's light meter. Using one of four accessory antennas for covering VHF, UHF, S, C, and X bands, the antenna is faced toward the radiating source and the density of the radiating field is read directly from the instrument scale on which safe and unsafe levels are coded in green and red respectively.

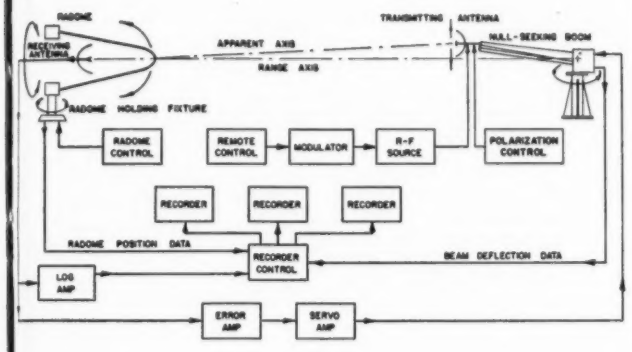
Internal mercury cell batteries with an operating life of over 100 hours power the meter, which measures a maximum density of 20 mw/cm², with accuracy and sensitivity both ±1 db. The meter is also used by armed forces personnel as a simple field test monitor for checking the operation of transmitters, including radars, over the 200 to 10,000 mc range.

FOR MORE INFORMATION CIRCLE 248 ON READER-SERVICE CARD

Radome Boresight-Errors Automatically Plotted

Accurate testing of radome boresight errors is required by MIL-R-7705A (ASG), because errors introduced through non-uniform composition of the plastic radar "eye" can seriously impair the plotting or control accuracy of the radar.

A new Automatic Boresight-Error Measuring system records errors directly in milliradians to an accuracy of ±0.1 milliradian, reads transmission efficiency through the radome in percent, and plots antenna patterns either with or without the radome, over frequencies from S through the K_a bands.



In operation, a transmitting parabola on the end of the Null-Seeking Boom directs a beam at the radome and receiving antenna located at the opposite end of the boresight range. Mounted on a fixed pedestal, the conically-scanning receiving antenna is located in the identical configuration and is the same antenna to be used in the actual aircraft or missile installation. The received signal, by means of the Error and Servo Amplifiers, is used to position the Null-Seeking Boom to the apparent axis of the receiving antenna as seen through the deflecting radome. A 1-inch deflection of the Boom on a 1000-inch range is equivalent to 1-milliradian beam shift. While the motor-driven Radome Holding Fixture rotates, three Recorders plot directly in milliradians the magnitude and the horizontal and vertical components of the beam deflection angle as represented by the position of the Null-Seeking Boom.

When making radome transmission efficiency measurements or plotting antenna patterns, the transmitting antenna is held fixed on the range axis and the null-seeking portion of the system is not used. The Log Amplifier, a high-gain bolometer amplifier having both logarithmic and linear channels, is used to drive one of the Recorders. The turntable of the Radome Holding Fixture is used when testing antennas, and the Log Amplifier enables patterns to be plotted directly in db on conventional linear paper.

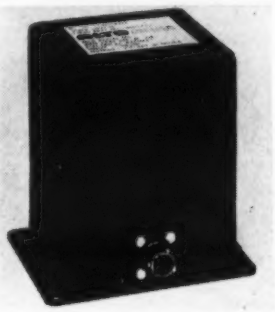
The blocks shown in the system are complete physical units which may be purchased separately, enabling the user to augment existing test ranges or to use only the components necessary for transmission or pattern measurements.

(*From Model* 150 *C Data Sheet, California Technical Industries, Div. of Textron, Inc., Belmont, Calif.*)

FOR THIS LITERATURE CIRCLE 179 ON READER-SERVICE CARD

AIRBORNE DC-DC CONVERTER

Model M116 airborne power supply converts 28 v dc (±10%) to an output of 350 v at 110 ma with a regulation of ±5% from 75 to 100% full load. Operates with a baseplate tem-

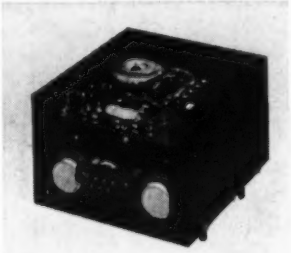


perature range of 30° to 135°F and will withstand storage from −65° to 160°F. Is protected against output short circuits and input spike voltages.—*Alto Scientific Co., Inc.*, 855 *Commercial St., Palo Alto, Calif.*

CIRCLE 180 ON READER-SERVICE CARD

POWER INVERTER

New Model 8251VT 100 va Amstat square wave inverter operates from 26-29 v dc over ambients from −54° to 71°C to supply 115 v at 400 cps

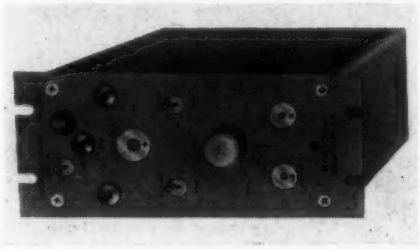


unregulated. Maximum weight is 3.5 lbs. Units from 10 va to 3 kva, 50 to 6000 cps, single and three-phase provide spike suppression, short-circuit proof circuitry and highest reliability.—*American Electronics, Inc., Elec. Machinery & Equip. Div.*, 2112 *No. Chico Ave., El Monte, Calif.*

CIRCLE 181 ON READER-SERVICE CARD

DC AMPLIFIER

Transistorized instrumentation amplifier Model DA-12 for laboratory dc applications features a noise of



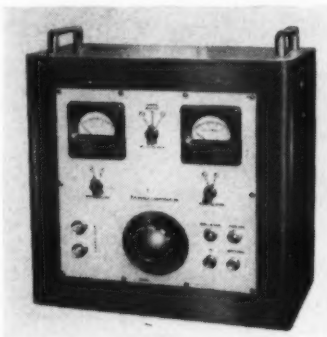
only 5 μv, peak-to-peak; step function response of 7 μsec and overload recovery time of 50 μsec.—*United ElectroDynamics, 200 Allendale Rd., Pasadena, Calif.*

CIRCLE 182 ON READER-SERVICE CARD

New Products—CONT.

HIGH VOLTAGE SUPPLIES

New Model KV30-5 andKV30-2.5 selenium rectifier power supplies rated at 0-30 kilovolts are designed



for industrial and laboratory operations including Cathode ray tubes, electrostatic precipitators and insulation tests. They supply currents of 5 and 2.5 ma respectively, protected against overloads in excess of 110%. —*Kilovolt Corporation, 2 Manor House Square, Yonkers, N. Y.*

CIRCLE 183 ON READER-SERVICE CARD

SNAP-ON RF CONNECTOR

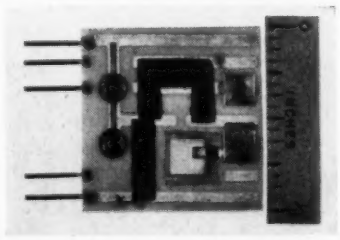
New snap-on versions of standard 50- and 75-ohm "ConheX" coaxial

couplings are provided with a spring ring around a slotted sleeve to provide firm coupling.—*Sealectro Corp., 139 Hoyt St., Mamaroneck, N. Y.*

CIRCLE 184 ON READER-SERVICE CARD

MICROCIRCUIT CAMERA

Army secrecy restrictions have been lifted on a method for producing micro-modular circuits, making the system available for general industrial use. A Micro Module Camera

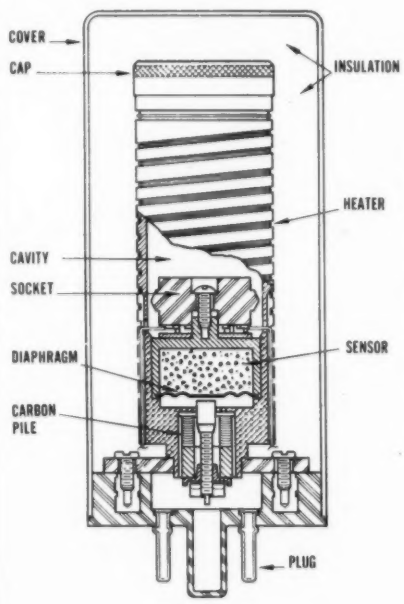


with special lens reduces large wiring designs down to tiny plastic wafers (See Fig.) Other parts are then added by microscopic techniques to make smaller and lighter missile control systems.—*Burke & James, Inc., 321 S. Wabash Ave., Chicago 4, Ill.*

CIRCLE 185 ON READER-SERVICE CARD

Change-of-State Stabilizes Crystal Oven

A crystal oven using a new approach to temperature stabilization utilizes the familiar "heat of crystallization" to achieve a unique level of temperature stability for frequency-control crystals and other temperature sensitive elements. Utilizing a natural principle of temperature stabilization similar to that which maintains a freezing or melting block of ice at exactly 0°C during its change-of-state; the Thermal-Set oven, a development of the Aeronautical and Instrument Division of Robertshaw-Fulton, uses a chemical sensor consisting of a pure crystalline salt which exists in a partially-liquid, partially-solid state at its fusion temperature. In operation, the salt absorbs heat by a change to greater proportion of



PROPORTIONED heat control, instead of "On-Off" regulation, is achieved by new crystalline sensor which changes state with gain or loss of heat at constant temperature.

liquid; or gives up heat while passing from liquid to a solid state. Oven cavity temperature therefore, is determined by the melting point of the crystal salt and is virtually insensitive to ambient temperature changes. Standard temperatures are 53°, 70° and 87°C.

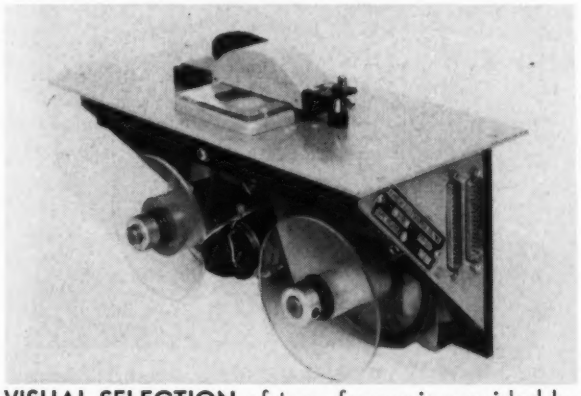
Control of heat to and from the oven cavity is achieved through use of a carbon pile. As heat dissipates from the oven cavity, the chemical sensor contracts due to a phase shift toward a more solid composition. Contraction of the salt deflects a diaphragm which transmits pressure to the base of the carbon pile, decreasing its resistance to heater current. Heat transfer to the oven cavity, on the other hand, causes proportionately less current flow to the heater. In this manner, thermal regulation is achieved through proportioned heat control, without the usual adverse effects of thermal oscillation and contact noise associated with conventional "on-off" regulation.

Engineering details of the new oven are described in a 2-page Technical Bulletin RF-594, published by Robertshaw-Fulton Controls Co., Santa Ana Freeway at Euclid Ave., Anaheim, Calif.

FOR MORE INFORMATION CIRCLE 186 ON READER-SERVICE CARD

Punched Tape Readers Provide Flexible Programming

A new series of punched tape readers, designed especially for use in automatic test equipment, allow visual selection of tape frames by means of information printed directly on the tape. The basic model, TP-201A, illustrated below, uses tape that is two inches wide, with one inch for punched information and one inch for printed information enabling visual selection of any one-inch 80-bit frame within the 250 feet of stored tape. The window for visual reading is shown alongside the electrical reading head above the reader panel. Applications are in ground checkout, production testing, automatic sequencing, numerical programming and automation in general.



VISUAL SELECTION of tape frames is provided by printed information on tape in new punched tape reader.

The reader head uses 80 spring-loaded pins which are gold plated for low contact resistance and rated at 0.050 amperes resistive. Common return is made through the sprocket drum which also is gold plated. The pins are arranged in ten transverse rows of 8 pins each. Tape drive, detent and reader head are electrically interlocked so that the tape cannot stop between detent positions and the tape cannot be driven while the head is in a READ position. Drive, detent and reader head are solenoid actuated.

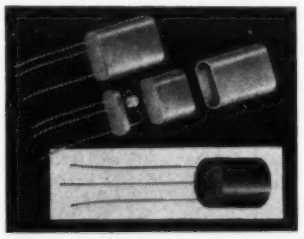
The curved reader head with its spring-loaded contact pins is normally raised off the tape during the time that the tape is moving and is only pulled into contact with the tape when a readout is desired. Bi-directional 26.5 v dc electrical drive system provides either sequential or random access to any of the 3000 discrete test positions which may be set up on a single 250 ft tape.

Three other available models use standard one-inch tape providing 80-bits of simultaneous information, two separate one-inch tapes for reading 160 bits simultaneously; or three one-inch tapes for reading 240 bits simultaneously. None of these models provide the printed indexing feature of the basic model. Standard tape punching equipment may be used to prepare the tapes which use the standard teletype (0.1″ centers) configuration. Additional information on specifications and delivery can be obtained from the manufacturer, *Anaheim Electronics Co., Inc.*, 1016 *Raymond Way, Anaheim, Calif.*

FOR THIS LITERATURE CIRCLE 187 ON READER-SERVICE CARD

TRANSISTOR ENCAPSULATION

New aluminum-filled epoxy E-Form pellets provide 300% greater heat



dissipation, withstand shock to 100 G and simplify production. In shapes, sizes for both oval and JETEC packages.—*Epoxy Products, Inc.*, 137 *Coit St., Irvington, N. J.*

CIRCLE 188 ON READER-SERVICE CARD

SLIP RING ASSEMBLY

New microminiature slip ring assemblies comprise 21 rings, 42 brushes, meet requirements of MIL-

E-5400C. Current ratings 2 amperes for 6 rings, 1 ampere for 15 rings; Hi-pot test 500 v dc; withstands temperature from −65° to 350°F.—*Slip Ring Co. of America*, 3612 *W. Jefferson Blvd., Los Angeles* 16, *Calif.*

CIRCLE 189 ON READER-SERVICE CARD

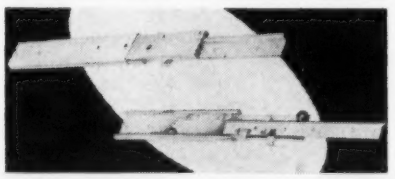
MODULAR VALVE COMPONENTS

Several varieties of custom designed modular valve components can be inserted in pump housings, cored manifolds or combined into space-saving control box. Modules are readily installed or replaced. Check, bypass relief, shuttle and other types for pressures to 10,000 psi.—*James, Pond & Clark, Inc.*, 2181 *E. Foothill Blvd., Pasadena, Calif.*

CIRCLE 190 ON READER-SERVICE CARD

CABINET SHELF SLIDES

New Type 324 "Budgeteer 3-section ball-bearing slide features extended



position-locking, Mil-Spec approval, 150 lb rating and quick disconnect mechanism.—*Grant Pulley & Hardware Corp., High St., West Nyack, N. Y.*

CIRCLE 191 ON READER-SERVICE CARD

DUAL FUEL FILTER

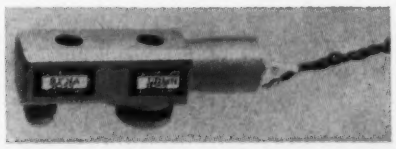
New Bypass fuel filter No. 52-2290-000 uses two cleanable and re-

useable filters. Primary filter actuates signal and shunts flow to second filter if it is clogged, permitting aircraft to complete mission.—*Aero Supply Mfg. Co., Corry, Pa.*

CIRCLE 192 ON READER-SERVICE CARD

BI-PROPELLANT VALVE

Normally-closed, explosive-operated valve, Model 1005, simultaneously opens both fuel and oxidizer lines of



prepackaged rocket engine on application of 1 amp for 20 msec. For pressures to 1500 psi.—*Pyronetics*, 11973 *E. Slauson, Santa Fe Springs, Calif.*

CIRCLE 193 ON READER-SERVICE CARD

MSD new literature

SHORTEST MICROWAVES enable new techniques in research using 140 Kmc components and devices described in 12-page Bulletin 140.—DeMornay-Bonardi, 780 S. Arroyo Parkway, Pasadena, Calif.

CIRCLE 194 ON READER-SERVICE CARD

RADAR SYSTEM STABILITY tests on stalos, cohos and other signal sources are explained in 4-page Series 800 Stalo Tester brochure.—Pitometer Log Corp., 237 Lafayette St., New York 12, N. Y.

CIRCLE 195 ON READER-SERVICE CARD

PLANAR TRIODES and Klystrons for microwave communications and measurement equipment are described in 4-page catalog.—Sylvania Electric Products Inc., Special Tube Operations, 500 Evelyn Ave., Mountain View, Calif.

CIRCLE 196 ON READER-SERVICE CARD

WAVEGUIDE FILTERS in tunable preselection, band rejection cutoff, and bandpass cavity types are described for 8.5-9.6 Kmc range in 4-page "Waveguide Filter" brochure.—Waveline, Inc., Passaic Ave., Caldwell, N. J.

CIRCLE 197 ON READER-SERVICE CARD

TRAVELING WAVE Tube P. M. Focused amplifiers and other microwave instruments are described in new 4-page catalog.—Menlo Park Engineering, 711 Hamilton Ave., Menlo Park, Calif.

CIRCLE 198 ON READER-SERVICE CARD

FILTERS in AF and HF ranges are listed with specifications in data sheet No. 601.—Control Electronics Co., 10 Stepar Place, Huntington Station, N. Y.

CIRCLE 199 ON READER-SERVICE CARD

MINIATURE Coaxial Remote controlled switch for 0-6000 mc range is described in new data sheet.—General Communication Co., 677 Beacon St., Boston 15, Mass.

CIRCLE 200 ON READER-SERVICE CARD

PULSE WIDTH DISCRIMINATOR filter device for improving S/N ratio in pulse sensory systems is described in new 6-page technical brochure.—Mini-Rad, Inc., 7416-E Varna Ave., No. Hollywood, Calif.

CIRCLE 201 ON READER-SERVICE CARD

TELEMETRY AMPLIFIER MODULES to drive voltage-controlled oscillators are described in "SCAMP" system 2-page brochure.—Neff Instrument Corp., 2211 E. Foothill Blvd., Pasadena, Calif.

CIRCLE 202 ON READER-SERVICE CARD

FM TELEMETERING system for accurate measurement of continuous analog data and conversion for magnetic recording or telemetering is described in 6-page bulletin No. 104.—Wiancko Engrg. Co., 255 No. Halstead Ave., Pasadena, Calif.

CIRCLE 203 ON READER-SERVICE CARD

RELAY TESTING procedures and definitions are provided in new 70-page progress report of NARM Technical Committees.—National Assn of Relay Mfgrs., Att. Prof. Charles G. Cameron, P. O. Box 6, Stillwater, Okla.

CIRCLE 204 ON READER-SERVICE CARD

AUTOMATIC TEST for Tacan transceivers, reducing acceptance test time from 14 hr to ½ hr, is described in 4-page bulletin 321A.—Stromberg-Carlson, Electronics Div., Rochester 3, N. Y.

CIRCLE 205 ON READER-SERVICE CARD

ENVIRONMENTAL TEST facilities used in reliability and performance tests of TDI telemetry equipment are described in new 8-page bulletin 859.—Tele-Dynamics Inc., 5000 Parkside Ave., Philadelphia 31, Pa.

CIRCLE 206 ON READER-SERVICE CARD

MISSILE ELECTRONICS systems programs underway in four subsidiary laboratories are described in 4-page facilities brochure.—General Precision Equip. Corp., 92 Gold St., New York 38, N. Y.

CIRCLE 207 ON READER-SERVICE CARD

AUTOMATIC CHECKOUT equipment for Go/NoGo testing at any maintenance level and applicable to any type system is described in new 2-page bulletin.—Curtiss-Wright Corporation, Santa Barbara Div., 6767 Hollister Ave., Goleta, Calif.

CIRCLE 208 ON READER-SERVICE CARD

ESAKI, VARACTOR and other new diodes are discussed in 17-page "Applications" booklet by A. Uhlir, Jr.,—Microwave Associates, Inc., Burlington, Mass.

CIRCLE 209 ON READER-SERVICE CARD

NPN and PNP SWITCHING TRANSISTORS for medium and high-speed applications are described with complete specifications and suggested circuits in new 26-page catalog.—Semiconductor Div., Sylvania Electric Products, Inc., 100 Sylvania Rd., Woburn, Mass.

CIRCLE 210 ON READER-SERVICE CARD

SILICON and Germanium diodes, transistors, rectifiers, optics and other semiconductor products are listed with characteristics in new 8-page short-form all-products catalog.—Hughes Semiconductor Div., Hughes Products, Newport Beach, Calif.

CIRCLE 211 ON READER-SERVICE CARD

NPN-PNP Complementary Germanium alloy junction power transistors are described in new Bulletin E-355.—CBS Electronics, 100 Endicott St., Danvers, Mass.

CIRCLE 212 ON READER-SERVICE CARD

Fire Control Boresight Test

The Antenna Boresight Test Set No. 511D19 (Fig. 1) is used to measure any misalignment between the electrical and optical axes of the MD-7 Fire Control System Antenna (Fig. 2). This measurement is accomplished by correctly orientating the electrical axis with respect to a remote fixed point and then reading

FIG. 1. UHF TRANSMITTER and optical target are combined in Boresight Test Set used to calibrate MD-7 Fire Control System for defense of Convair "Hustler".

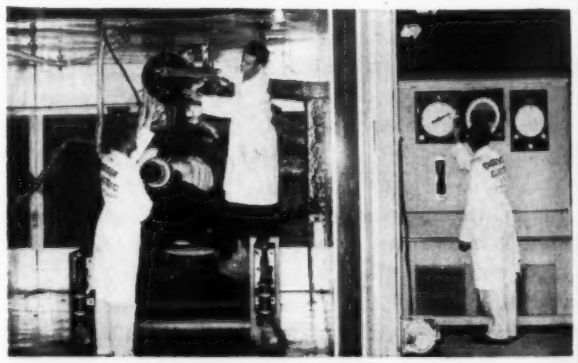


FIG. 2. MD-7 FIRE CONTROL system is mounted on test pedestal for boresight calibration. Control-Indicator unit, shown at right, houses circuitry, transmitter controls and self-check indicators.

the optical-electrical misalignment by observing a second such fixed point through a boresight telescope mounted on the antenna under test. The misalignment of optical to electrical axis is then read on the calibrated scale of a target located on the transmitter assembly. The indicated boresight error between the axes is determined to within ±0.2 milliradians.

These electrical and optical reference points consist of a K_M band ultra-high frequency transmitting source and a calibrated optical target, their relative positions being accurately set in the construction of a transmitter unit. Correct orientation of the antenna position is made possible by mounting the antenna on

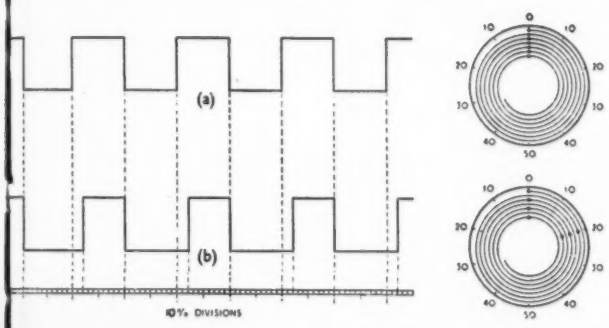
an antenna pedestal capable of movement in aximuth and elevation.

The Antenna Boresight test set is a component of a complete system of automatic check-out equipment developed by the Emerson Electric Mfg., Co., St. Louis 21, Mo. for the ground support of the MD-7 fire control system for the defense of the Convair B-58 "Hustler" bomber.

FOR MORE INFORMATION CIRCLE 213 ON READER-SERVICE CARD

Measuring Distortion in Data Signal Systems

New Telegraph Distortion Measurement and Monitoring Systems (TDMS) provides complete wave-form analyses of all commonly-used telegraph systems and most data-transmission and communications networks. TDMS instrument units comprise an A-scan oscilloscope, transmitter and receiver, mounted in a test rack which contains a regulated power supply.



BIAS DISTORTION and corresponding displays on TDMS Receiver: (a) ac reversals, zero bias show perfect signals. (b) 20% spacing bias from delay in space-mark changeovers.

Analysis of incoming signal distortion is made by the receiver unit which displays a circular or spiral cathode ray display from which distortion may be read directly. Malfunctions can be pinpointed and remedied without interrupting the flow of traffic. The transmitter unit can generate signals with from 0 to 50% of controlled distortion for the adjustment of systems and relays while they are operating.

Synchronous signals are displayed on a circular trace, while start-stop signals are presented on a spiral trace. Each character element appears as a bright dot on a different spiral loop to aid in the direct measurement of individual distortion. Input signals may be of either polarity.

With a non-distorted signal, all dots will form a vertical line. Long or short start signals will displace dots either to the right or left of the vertical line. Bias distortion (See Figure) also end, characteristic and fortuitous distortion can be determined from the relative displacement of individual dots on the spiral scan.—(*From new 12-page Bulletin RAD E-100B, Radiation, Inc., P. O. Drawer 37, Melbourne, Fla.*)

FOR THIS LITERATURE CIRCLE 214 ON READER-SERVICE CARD

ANTENNA MULTICOUPLERS for connecting 10 receivers to one antenna in HF range are described in new data sheet.—CGS Laboratories, Inc., Wilton, Conn.

CIRCLE 215 ON READER-SERVICE CARD

TRANSISTOR AMPLIFIERS for data and instrumentation miniaturized systems are explained in new 6-page folder.—Taber Inst. Corp., 107 Goundry St., North Tonawanda, N. Y.

CIRCLE 216 ON READER-SERVICE CARD

LOW-LEVEL PULSE TRANSFORMER design and application is explained in new 18-page technical brochure and catalog. Differences from other transformer types, methods of measurement core degaussing are also included. PCA Electronics, Inc., 16799 Schoenborn St., Sepulveda, Calif.

CIRCLE 217 ON READER-SERVICE CARD

ENCAPSULATED TRANSFORMERS with basic design improvements for Mil-Spec use are described in new 4-page brochure.—Electro Engineer Works, 401 Preda St., San Leandro, Calif.

CIRCLE 218 ON READER-SERVICE CARD

DC MAGNETIC Amplifiers powered from 60 to 400 cps for use in control and sensitive measurement systems are described in PREAC Bulletin M-62.—Airpax Electronics Inc., Fort Lauderdale, Fla.

CIRCLE 219 ON READER-SERVICE CARD

MINI Inductors meeting Mil-Specs and ranging from 0.10 to 4700 μH are described in new data sheet.—Essex Electronics, Div. of Nytronics, Inc., 550 Springfield Ave., Berkeley Heights, N. J.

CIRCLE 220 ON READER-SERVICE CARD

MAGNETIC MODULATOR characteristics and variations are described in new 4-page "Mag-Mod" folder.—General Magnetics, Inc., 135 Bloomfield Ave., Bloomfield, N. J.

CIRCLE 221 ON READER-SERVICE CARD

HYSTERESIS Synchronous (Hysyn) precision motors in single and two-speed types, 28 to 220 v, 50 to 440 cps, and 360 to 1800 rpm ratings are described in 4-page data folder.—Hysyn Electromotive, 915 No. Citrus Ave., Los Angeles 38, Calif.

CIRCLE 222 ON READER-SERVICE CARD

SERVO ANALYZER automatically computing and plotting of gain-phase servo system signals is described in 4-page Metrolog 200 bulletin.—Metrolog Corp., 169 N. Halstead St., Pasadena, Calif.

CIRCLE 223 ON READER-SERVICE CARD

DIGITAL DATA logging system scanning 20 analog strain-gage channels is described in Data Sheet 2007.—Franklin Electronics, Inc., Bridgeport, Pa.

CIRCLE 224 ON READER-SERVICE CARD

NPN SILICON Power transistors rated to 50 watts are described in new data sheet.—Silicon Transistor Corp., Carle Place, L. I., N. Y.
CIRCLE 225 ON READER-SERVICE CARD

MILITARY COMPUTER techniques are described in new 20-page facilities Bulletin GEA-59APJ-75.—General Electric Co., LMED, 600 Main St., Johnson City, N. Y.
CIRCLE 226 ON READER-SERVICE CARD

TWO-and THREE-DIMENSION automatic multichannel plotting systems for jet-speed data and situation displays are described in new 22-page bulletin.—Fenske, Fedrick & Miller, Inc., 12820 Panama St., Los Angeles 66, Calif.
CIRCLE 227 ON READER-SERVICE CARD

EDGE-PUNCHED Data Cards or punched -tape methods of paper-work automation in data processing are described in new 4-page brochure.—Remington Rand Div., Sperry Rand Corp., 315 Park Ave. So., New York 10, N. Y.
CIRCLE 228 ON READER-SERVICE CARD

MISSILE STRUCTURE ANALYSIS by automatic high-speed data reduction system is described in new 2-page system design bulletin ES-006.—Epsco Systems, 588 Commonwealth Ave., Boston, Mass.
CIRCLE 229 ON READER-SERVICE CARD

STRAIN GAGE and transducer input circuits for multichannel data aquisition system are described in new 6-page Bulletin BBU-C-9-59.—B & F Instruments, Inc., 3644 N. Lawrence St., Philadelphia 40, Pa.
CIRCLE 230 ON READER-SERVICE CARD

ACCELEROMETER Transducer (Data Sheet 2600) and Amplifier (Data Sheet 2200) design data are available.—Endevco Corp., 161 E. California Blvd., Pasadena, Calif.
CIRCLE 231 ON READER-SERVICE CARD

PRECISION WIREWOUND fixed resistors and composition variable resistors meeting Mil-specs list technical data in new 24-page engineering catalog—Reon Resistor Corp., 155 Saw Mill River Rd., Yonkers, N. Y.
CIRCLE 232 ON READER-SERVICE CARD

SIZE 11 Vernistat AC potentiometers for miniaturized function generation are described in Series 4 Data Sheet.—Vernistat Div., Perkin-Elmer Corp., Norwalk, Conn.
CIRCLE 233 ON READER-SERVICE CARD

MINI PRESSURE Transducers and transducer amplifiers for airborne and missile telemetry systems are described in 2-page data sheet, "Teleflight 180".—Taber Instrument Corp., 107 Goundry St., North Tonawanda, N. Y.
CIRCLE 234 ON READER-SERVICE CARD

PRESSURE TRANSDUCERS and solid-state relays are listed with characteristics in new 4-page Celab catalog.—Clark Electronic Laboratories, Box 165, Palm Springs, Calif.
CIRCLE 235 ON READER-SERVICE CARD

CAPACITANCE Temperature Coefficient measurement to accuracy of 1 ppm is described in new 2-page 74-C brochure.—Boonton Electronics Corp., Morris Plains, N. J.
CIRCLE 236 ON READER-SERVICE CARD

CAPACITORS in drawn-rectangular cases using Difilm dielectric and impregnated with Vitamin-Q are smaller and do not require derating under 125°C. Described in 12-page Engineering bulletin No. 2340.—Sprague Electric Co., North Adams, Mass.
CIRCLE 237 ON READER-SERVICE CARD

HYDRAULIC FLOW Regulators for missile, aircraft and ground support actuator control applications are described in 4-page bulletin A-300.—Waterman Engineering Co., Box 391, Evanston, Ill.
CIRCLE 238 ON READER-SERVICE CARD

JET FUEL PUMP of balanced vane type is described with performance data in 4-page Bulletin a5242.—Vickers, Inc., Detroit 32, Mich.
CIRCLE 239 ON READER-SERVICE CARD

HYDRAULIC FILTER assembly for converting existing service carts to 3-micron clarity is explained in 6-page technical proposal.—Aircraft Porous Media, Inc., Glen Cove., N. Y.
CIRCLE 240 ON READER-SERVICE CARD

MAGNETIC RECTIFIER Controls to drive GE Silicon Controlled Rectifiers are described in new 8-page bulletin MRC 658.—Fairfield Engineering Corp., 934 Hope St., Springdale, Conn.
CIRCLE 241 ON READER-SERVICE CARD

POWER SUPPLIES for TWT, Klystron and T-R Keep-alive uses are described in new data sheet.—Burmac Electronics Co., Inc. 142 So. Long Beach Rd., Rockville Centre, L. I., N. Y.
CIRCLE 242 ON READER-SERVICE CARD

DC-DC POWER Supplies for mobile receiver and transceiver installations are described in 4-page catalog.—Universal Transistor Products Corp., 17 Brooklyn Ave., Westbury, L. I., N. Y.
CIRCLE 243 ON READER-SERVICE CARD

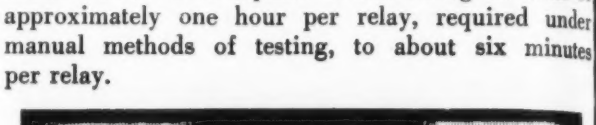
SILVER-ZINC Automatically activated Primary Batteries are described in new 6-page brochure.—Cook Batteries, 3850 Olive St., Denver 7, Colo.
CIRCLE 244 ON READER-SERVICE CARD

EXPLODING BRIDGEWIRE system for initiation of rocket motors and other explosive actuators as replacement for squibs and detonators is described in 6-page EBW brochure.—Librascope/Sunnyvale, 670 Arques Ave., Sunnyvale, Calif.
CIRCLE 245 ON READER-SERVICE CARD

"EVERYTHING IN ELECTRONICS" is title of 522-page 1960 Catalog No. 190-A.—Allied Radio, 100 N. Western Ave., Chicago 80, Ill.
CIRCLE 246 ON READER-SERVICE CARD

New Relay Tester

Design for the third model of relay tester to be brought out by the Anaheim Electronics Co., Inc., of Anaheim, Calif., is nearing finalization. Although minor changes are still considered, the new device, designed to facilitate receiving inspection testing of all types of miniature relays, will essentially be that shown below. It is capable of shortening the time of approximately one hour per relay, required under manual methods of testing, to about six minutes per relay.



The new tester, designated Model RT-905, uses adaptors to test both plug-in and solder terminal types of relays for the following parameters:

1. Pull-in and drop-out current and voltage.
2. Coil resistance.
3. Contact resistance.
4. Insulation resistance (using external megger wired thru test switch to test sockets).
5. Pull-in and drop-out time, armature transfer time.
6. Contact bounce.

Five ammeter scales for coil and contact current (15 ma to 5 amp); three voltmeter scales, 50 mv for contact voltage drop, 50 and 150 v scales for coil voltage; and three ohmmeter ranges for coil resistance are provided. Test jackets for external ac meters are also available for testing of ac relays. Test points for using an external oscilloscope permit measurement of pull-in and drop-out time and contact bounce. The testing circuit enables either a manual control of coil voltage or three repetition rates for switching coil voltage on and off automatically. Also provision is made for testing polarized and latching relays.

FOR THIS LITERATURE CIRCLE 247 ON READER-SERVICE CARD

Government Defense Materials System Rules Amended

A new simplified DMS Reg-1 now makes mandatory the use of priority ratings and symbols by prime and sub-contractors on purchase orders for controlled materials needed to meet delivery schedules on Defense work. An exception to this mandatory identification rule is made for individual purchase orders for $500 or less. The new rules apply to all persons engaged in production, construction, or research and development for defense programs. Copies of the amended regulation may be obtained from Commerce Dept field offices or from the Business and Defense Services Admin., Washington 25, D. C.

MSD advertisers' index

This index is published as a service. Every care is taken to make it accurate, but MSD assumes no responsibility for errors or omissions.

CIRCLE 61 ON READER-SERVICE CARD →

MSD events

January 25-29, 1960—Stress Measurement Symposium, Arizona State University, Tempe, Ariz., Registration fee $200. Write STRAIN GAGE READINGS, 5602 E. Monte Rosa, Phoenix, Ariz.

February 3-5—1960 Winter Convention on Military Electronics, Biltmore Hotel, Los Angeles, Calif., PGME IRE. Write Warren Northwood, Space Technology Labs., 5730 Arbor Vitae, Los Angeles 45, Calif.

February 10-12—7th Annual Solid-State Circuits Conference, Univ. of Penna., Philadelphia, Penna. Sponsored by Univ. of Penna., IRE, AIEE. Write Tudor R. Finch Bell Telephone Labs., Inc., Murray Hill, N. J.

March 21-24—IRE National Convention, Coliseum and Waldorf-Astoria Hotel, New York, N. Y. Write E. K. Gannett, Institute of Radio Engineers, 1 East 79th St., New York 21, N. Y.

March 24-25—1st Annual Symposium on Human Factors in Electronics, New York City. Those interested in presenting papers or suggesting symposia write Mr. R. R. Riesz, Chmn Papers Procurement Comm., c/o Bell Telephone Labs, Murray Hill, N. J.

April 19-21—10th Annual Symposium of Active Networks and Feedback Systems, Engineering Societies Bldg., 33 W. 39th St., New York. Microwave Research Institute of Polytechnic Institute of Brooklyn. 100-word abstracts of papers accepted until Jan. 15, 1960; send to Prof. Herbert J. Carlin, Microwave Research Institute, 55 Johnson St., Brooklyn 1, N. Y.

June 16-18—Fifth Annual Symposium and Exhibit of the American Scientific Glassblowers Society, Penn-Sheraton Hotel, Pittsburgh, Pa. Twenty papers will be presented in five sessions by nationally recognized authorities in the glasss-working field. Write to W. E. Barr, Gulf Research & Development Co., P. O. Box 2038, Pittsburgh 20, Pa.